Advanced Review

The retreat from overgeneralization in child language acquisition: word learning, morphology, and verb argument structure

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This review investigates empirical evidence for different theoretical proposals regarding the retreat from overgeneralization errors in three domains: word learning (e.g., **doggie* to refer to all animals), morphology [e.g., **spyer*, **cooker* (one who spies/cooks), **unhate*, **unsqueeze*, **sitted*; **drawed*], and verb argument structure [e.g., **Don't giggle me* (c.f. *Don't make me giggle*); **Don't say me that* (c.f. *Don't say that to me*)]. The evidence reviewed provides support for three proposals. First, in support of the *pre-emption* hypothesis, the acquisition of competing forms that express the desired meaning (e.g., *spy* for **spyer*, *sat* for **sitted*, and *Don't make me giggle* for **Don't giggle me*) appears to block errors. Second, in support of the *entrenchment* hypothesis, repeated occurrence of particular items in particular constructions (e.g., *giggle* in the intransitive construction) appears to contribute to an ever strengthening probabilistic inference that non-attested uses (e.g., **Don't giggle me*) are ungrammatical for adult speakers. That is, both the rated acceptability and production probability of particular errors decline with increasing frequency of pre-empting and entrenching forms in the input. Third, learners appear to acquire semantic and morphophonological constraints on particular constructions, conceptualized as properties of slots in constructions [e.g., the (VERB) slot in the morphological *un*-(VERB) construction or the transitive-causative (SUBJECT) (VERB) (OBJECT) argument-structure construction]. Errors occur as children acquire the fine-grained semantic and morphophonological properties of particular items and construction slots, and so become increasingly reluctant to use items in slots with which they are incompatible. Findings also suggest some role for adult feedback and *conventionality*; the principle that, for many given meanings, there is a conventional form that is used by all members of the speech community.

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INTRODUCTION

Many different animal species have systems of communication that are remarkably sophisticated. However, human languages are unique in that they afford speakers the productivity to express new meanings. In some cases, this productivity involves extending an existing word to take on a new meaning (e.g., *spam*, *Google*). In others, a prefix or suffix is productively applied to new items (e.g., *un+subscribe; Bush+ism; Obama+ed*). Perhaps, the most impressive examples of productivity are seen

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when speakers combine words to produce entirely novel sentences, such as this one (or Chomsky's famous example *Colorless green ideas sleep furiously*). But this productivity comes at a cost. At all three levels, the mechanisms that yield this capacity suggest generalizations that would be considered unacceptable by native adult speakers (i.e., overgeneralizations). For example,

- at the lexical level, children overgeneralize words to referents for which they would not be appropriate for adults (e.g., **doggie* to a bear, a horse, and Cookie Monster).[1]
- at the morphological level, children overgeneralize derivational suffixes [e.g., **spyer*, **cooker* (one who spies/cooks)] and prefixes (e.g., **unhate*, **unsqueeze*), as well as inflectional morphemes (e.g., **sitted; *drawed*).[1]
- at the level of verb argument structure (syntax), children overgeneralize verbs into syntactic constructions with which they are incompatible [e.g., **Don't giggle me* (c.f. *Don't make me giggle*); *Don't say me that (c.f. *Don't say that to me*)].[2]

The purpose of this review is to summarize and evaluate the empirical evidence for different theoretical proposals about how children retreat from these errors, or—indeed—how some children apparently avoid some types of error altogether, while retaining the capacity for productive generalization.

OVERGENERALIZATION AT THE LEXICAL LEVEL

The earliest overgeneralization errors occur when a child extends a particular word to other referents that share some visual or conceptual similarity. One particularly extensive summary of early lexical development[1] presented a large number of such errors, including *doggie* (to all animals), *apple* (both to other round objects such as rubber balls and round lamps, and to other fruits such as strawberries, pears, and peaches), and *moon* (to a half grapefruit, a lemon slice, a dial on a dishwasher, and a shiny leaf). The same study concluded that such errors generally occur only up until around age 2;6. Traditionally,[3,4] these errors have been viewed as either category errors (e.g., the child incorrectly assigns the concept of 'ball' to her *apple* category) or pragmatic adaptions to vocabulary limitations (e.g., the child knows that the ball is not really an *apple*, but uses the word in her vocabulary with the closest available meaning, in order to make herself understood). However, the findings of a recent priming study conducted with young 2-year-olds[5] suggest that at least some errors may be errors of lexical retrieval. After correctly labeling a particular item (e.g., *cake*), some children incorrectly overextended this label to a perceptually similar item (e.g., a drum), even though they demonstrated knowledge of the correct label in a comprehension task. Nevertheless, whether or not they constitute true overgeneralization errors, some of the mechanisms that have been proposed to explain how children quickly retreat from these errors are also applicable to the more complex overgeneralization errors that occur later in development.

Pragmatic Principles: Conventionality and Contrast

A useful starting point is to ask exactly why it is incorrect to use (for example) the word *doggie* to refer to a bear, a horse, or Cookie Monster. One possible answer illustrates the principles of *conventionality* and *contrast*[6]:

> For certain meanings, there is a **conventional** form that speakers expect to be used in the language community; that is, if one does not use the conventional form that might have been expected, it is because one has some other **contrasting** meaning in mind (p. 319).

The principle of conventionality works against overgeneralization errors (e.g., *doggie* for a bear), as children are aware that, to be understood, they must use the conventional form used by other speakers (i.e., *bear*). The principle of contrast will assist in the retreat from overgeneralization in a similar way. If a child expects to hear *doggie* (her own overgeneralized word for *bear*) but hears *bear*, she can infer that *bear* is not simply a synonym for *doggie*, but has a different meaning.

Experimental evidence that children use the principles of conventionality and contrast comes from studies where children are shown two unfamiliar objects and taught the name for one (e.g., *mef*). When asked by an experimenter to (for example) 'Give me the *wug*', 3-year-old children overwhelmingly select the previously unlabeled object (82% of trials in Ref 7). A follow-up study[8] demonstrated that 4-year-old children understand that common nouns (e.g., *the melloo*), but not person names (*Melloo*), are conventional and known to all members of a speech community.

Interestingly, the principles of conventionality and contrast are not restricted to language. For example, if 3-year-old children are taught to perform a

novel action, they spontaneously assume a normative convention with regard to the way that the action is performed, and protest strongly if this norm is violated.[9] With regard to contrast, if children of this age are shown two unfamiliar objects and given an arbitrary fact about one (e.g., 'This is from Mexico'), when asked—for example—for 'The one my dog likes to play with', they will select the other.[7]

OVERGENERALIZATION AT THE MORPHOLOGICAL LEVEL

Another domain in which overgeneralization errors have been observed is derivational morphology. For example, the suffix *-er* can be added to many verb stems to create a noun with the meaning of a person or thing that performs the relevant action [e.g., *swim(m)+er*, *run(n)+er,* and *comput(e)+er*]. Through application of this generalization, children have been reported to produce innovative nouns such as **spyer*, **cooker*, **applier, *whisker* (for *whisk*), and **driller* (for *drill*)[1] and—via backformation (i.e., application of this rule in reverse)—innovative verbs such as **to ham* (hit with hammer), **to hoove* (vacuum with Hoover), and **to dag* (stab with dagger).[10] Similarly, the prefix *un-* can be added to many verbs to denote the reversal of an action (e.g., *untie* and *unwrap*), but children often overgeneralize this rule to yield forms such as **to unblow* (deflate), **to unlight* (extinguish, of a fire), **to unpull* (undo, of a belt), **to unappear* (disappear), and **to unsqueeze* (release, let go).[2,11]

Pre-emption

One mechanism that seems to be particularly important with regard to errors of this type is *pre-emption*[12]:

> If a potential innovative expression would be precisely synonymous with a well-established expression, the innovation is normally pre-empted by the well-established term, and is therefore considered ungrammatical (p. 798).

Pre-emption is very similar to the pragmatic principles of conventionality and contrast. If there is a difference, it is perhaps that pre-emption applies more to overgeneralizations that involve new coinages (e.g., **spyer* and **to unblow*) as opposed to the overextension of existing terms (e.g., **doggie* for *bear*). The authors who first used the term in this context distinguish three types of pre-emption (see Ref 12, p. 81–82). Pre-emption by *suppletion* occurs when an overgeneralized form is blocked by an existing form with an unrelated root (e.g., *deflate* for **unblow*). Pre-emption by *entrenchment* occurs when an overgeneralized form is blocked by an existing form with the same root (e.g., *applicant* for **applier* and *disappear* for **unappear*). Pre-emption by *ancestry* occurs when, for example, a verb (e.g., *to drill* and *to whisk*) was created from a noun in the first place (*drill* and *whisk*), with this original noun pre-empting a new coinage with the same meaning (**driller* and **whisker*). Although these distinctions are not particularly important for our purposes here—all are cases of the overriding principle of contrast/pre-emption—some of the subtypes are more important than others for other types of overgeneralization errors, discussed in subsequent sections.

Pre-emption is also sometimes known as *blocking*,[13] a term that highlights the roots of the concept in the animal-learning literature. If an animal has learned that an unconditioned stimulus (e.g., food) is fully predicted by one conditioned stimulus (e.g., a bell), then it has great difficulty learning that a second conditioned stimulus (e.g., a tone) also predicts the unconditioned stimulus.[14] A related concept from the word-learning literature is *mutual exclusivity*[15] (or the *novel name-nameless category principle*) which 'leads children to prefer only one label per object',[16] itself very similar to the principles of *conventionality* and *contrast* (see above). A detailed discussion of the differences and relationship between these proposals is beyond the scope of this article (though see Ref 17, p. 78–80 for one such attempt). Here, we note simply that the mechanisms lie on a continuum from blocking (completely domain-general; indeed species-general) through conventionality/contrast (general to non-linguistic types of learning; e.g., fact-learning) and pre-emption (specific to language, but encompassing word learning, morphology, and syntax) to mutual exclusivity/novel name-nameless category (specific to word learning). This raises the possibility that the more domain-specific proposals reflect the operation of a more general learning mechanism, viewed through the lens of a particular domain or debate (e.g., word learning and syntax).

Semantic Constraints

Pre-emption is almost certainly the major mechanism by which children retreat from errors where the overgeneralized form has a perfectly synonymous competitor (e.g., *spy, drill,* and *disappear* for **spyer, *driller,* and **unappear*); this is probably also the case for suppletive past-tense forms (e.g., *went* for **goed*, see the following section). However, some overgeneralization errors in this domain would not seem to

have perfectly synonymous competitors. For example, potential competitors for **unsqueeze* such as *loosen, ease up, release, let go*, and *remove* are not synonymous with the overgeneralized form, as they do not specify the reversal of a squeezing action. Broadening the scope of pre-emption to any form that expresses some part of the desired meaning is problematic. For example, many of the potential competitors for **unsqueeze* listed above would seem to pre-empt not only this over-general form but also perfectly acceptable forms such as *untie*, *remove*, and *untighten*. Thus, at least in the domain of *un-* prefixation, pre-emption is unlikely to be sufficient as a solution.

Another factor that is probably relevant here is verb semantics. It has long been thought that verbs that may be prefixed with *un-* form a probabilistic family-resemblance category, sharing meaning components such as *covering, enclosing, surface-attachment, circular motion, hand-movements*, and *change of state*, though no single property appears to be either necessary or sufficient for membership.[18,19] Indeed, one recent study[20] found that adult ratings of the extent to which individual verbs exhibited each of these properties could predict the relative unacceptability of overgeneralized *un-* forms (e.g., **unsqueeze, *unallow,* and **unstand*) as rated by both children (aged 5–6 and 9–10 years) and adults, using a continuous scale. This effect held after controlling for verb frequency, reversibility (as rated by another group of adults), and pre-emption, operationalized as the sum frequency of possible pre-empting forms (again suggested by adult informants). Interestingly, only the middle-age group (9–10 years) displayed an effect of pre-emption, perhaps because the younger children[5,6] had not yet acquired the relevant pre-empting forms, while the adults displayed a tendency toward binary performance (i.e., assigning a rating of 'completely unacceptable' to all *un-* forms that they considered not to exist, regardless of the availability or otherwise of pre-empting alternatives). A potentially useful way to conceptualize the semantic effects observed in this study is in terms of the degree of compatibility between the semantic properties of individual verbs and the VERB slot in an *un-(VERB)* morphological construction. This allows these errors to be understood within the same framework as other types of overgeneralization error, discussed in subsequent sections. Under the assumption that it takes learners some time to acquire the semantic features of both (1) the VERB slot and (2) individual verbs, this account predicts that semantics-based errors will persist into relatively late in development, a prediction that enjoys some support from naturalistic,[2,21] elicited production,[11] and judgment[20] studies. In conclusion, both some form of pre-emption (or contrast) and semantic constraints are probably necessary elements of a complete account of how children retreat from overgeneralization errors involving derivational morphology.

Inflectional Morphology

Probably, the most-studied overgeneralization errors in language acquisition[22] are those involving the regular English past-tense marker *–ed* (e.g., **goed, *throwed, *sleeped,* and **sitted*), termed *over-regularization* errors. Again, some form of contrast, pre-emption or *blocking* (the term used with a slightly more specific meaning here than in the discussion above) seems to play an important role. A number of studies[23–25] have demonstrated a negative correlation across verbs between the rate of overgeneralization error and the relative or absolute frequency of the correct form (e.g., *went, threw, slept,* and *sat*).

Again, though, pre-emption cannot be the whole story, as it cannot explain performance with novel items, for which no pre-empting past-tense form can be stored in memory. One possibility[26–28] is that children set up a rule for regular verbs (e.g., add *–ed*) and simply memorize the exceptions as a fixed list of stems to which a particular irregular rule applies (e.g., IF stem = [*sleep, weep, creep*] THEN *eep* → *ept*). A problem for this account is its prediction that 'morpholexical rules for irregular verbs do not generalize to novel items' (Ref 28, p. 273), because each rule applies only to the verbs annotated with that rule in memory. In fact, judgment and production studies[29–32] demonstrate that when given novel items consistent with particular irregular patterns (e.g., *fleep*), both adults and children generalize them readily (e.g., here producing—or rating as highly acceptable—*flept*). Another possibility is that learners set up probabilistic productive generalizations for irregular verbs, but inflect at least some regulars[a] using a default rule (add *–ed*), which steps in when no irregular form is found in memory, the *dual-route* or *words-and-rules* model.[32–35] Under this account, novel irregular forms (e.g., *flept*) are generated by phonological analogy with stored irregulars (thus explaining the findings outlined above), but novel regulars (e.g., *froed*) by 'a default suffix concatenation process capable of operating on any verb, regardless of its sound' (Ref 32, p. 2). Thus, this account predicts that, in judgment studies, 'the goodness of the suffixed (i.e., regular) past-tense forms does not decline as a function of distance from known suffixed forms' (Ref 32, p. 22). Although this prediction was supported in these authors' own study, two subsequent studies with more tightly controlled stimuli[29,30] have found precisely the opposite. The

acceptability of a novel regular form (e.g., *froed*) is indeed increased by the availability of phonological 'friends' (e.g., *show-showed*).

These findings support *a single-route* model[31,36,37] under which both 'regular' and 'irregular' past-tense forms (this account assumes that the distinction is not psychologically meaningful) are stored and used as the basis for analogical generalization. Indeed, as suggested above for *un-* prefixation errors, it may be possible to also explain past-tense errors in terms of the probabilistic fit between properties of individual verb(-stem)s and those of competing morphological constructions [e.g., (VERB)+t as in *missed, kissed*; (VERB)+ed as in *needed, seeded*; (VERB)+vowel change as in *sang, rang*].[38] The difference is that, in this case, these properties are phonological rather than semantic in nature. In fact, it may be necessary to incorporate a role for semantic properties too. One judgment study[39] demonstrated that participants preferred a novel irregular past-tense form (*frank*) when the stem (*frink*) was similar in meaning to *drink/drank* and a regular past-tense form (*frinked*) when it was similar in meaning to *blink/blinked*. Although this manipulation clearly suffers from demand characteristics ('Does the experimenter want me to treat *frink* as a distorted version of *drink*, or of *blink*?'[40]), another part of the study demonstrated a more convincing role for semantics. When coining a new verb (e.g., *to stick*, meaning to hit with a stick), speakers may avoid assigning it an irregular past-tense form that already exists with a different meaning (e.g., *stuck*), and instead use a regular form (e.g., *sticked*). This study showed that ratings of semantic extendedness (e.g., how dissimilar are 'hitting with a stick' and 'become immobile') predicted the relative acceptability of the different forms (*sticked/stuck*). Counter to the predictions of a rival account,[41] grammatical status of the stem (denominal/deverbal) did not.

The advantage of this concept of competing morphological constructions is that, in addition to yielding the pattern of results outlined above, it potentially allows all types of overgeneralization error—including syntactic overgeneralization errors, as discussed in the following section—to be understood within the same framework. Note that the assumption of competition in memory between different forms that express the speaker's message is shared by proposals from otherwise very different theoretical frameworks.[42–44]

For languages with richer inflectional morphology, constraining generalization does not generally entail retreating from the over-application of a single 'regular rule' (e.g., add *–ed*). Rather, learners must learn to predict the appropriate morphological behavior of (primarily) nouns and verbs on the basis of distributional/morphophonological and semantic properties that operate and interact probabilistically. Consider, for example, the phenomenon of genitive case marking in Polish. Masculine nouns that take the marker *–a* (as opposed to *–u*) often, but not always, end in one of a handful of derivational suffixes (e.g., *-acz, -ak, -ek, -arz, -nik,* and *-ec*) and often, but not always, refer to smaller, concrete objects. Consequently, one study found that even young teenagers were not yet demonstrating adult-like performance.[45] Similar findings have been reported for other highly inflected languages, including Finnish,[46] Spanish,[47] Italian,[48] Dutch,[49] and Serbian.[50] Another distributional/morphophonological factor that seems to be important is phonological diversity. A study of Polish children's productivity with genitive, accusative, and dative case marking found that children were most productive with morphemes that apply to a large, phonologically diverse class.[51] Such findings have often been taken as evidence of a role for 'type frequency',[52] with classes or patterns that apply to more items being more productive. In fact, this is probably an oversimplification. First, a number of computer modeling studies have demonstrated that it is a high degree of phonological diversity, rather than type frequency *per se*, that seems to yield increased productivity.[53–55] Second, an elicited imitation study[56] found that 2- and 3-year-old children's productivity is best predicted by a measure that takes into account the relative frequency of occurrence of each item within a particular pattern (one type of *entropy* measure).

VERB ARGUMENT-STRUCTURE (SYNTACTIC) OVERGENERALIZATIONS

A verb argument-structure overgeneralization error occurs when a child uses a verb (e.g., the intransitive-only verb *disappear*) in an argument-structure construction in which it is considered ungrammatical by adult speakers (e.g., the transitive-causative construction; e.g., **Do you want to see us disappear our heads?*[2]). The generalization that has been overextended here is one that allows verbs that have been attested only in the intransitive construction to appear in the transitive-causative construction and vice versa (e.g., *The ball bounced/rolled/moved*; *The man bounced/rolled/moved the ball*). Although the majority of research has been conducted in English, *transitive-causative overgeneralization errors* of this type have also been observed amongst learners of

BOX 1

POSSIBLE AND ATTESTED VERB ARGUMENT-STRUCTURE OVERGENERALIZATION ERRORS

Attested errors (all from Ref 2) are shown in bold, with the age of the child (years;months) and a possible grammatical formulation using the alternate construction.

	Construction (a)	**Construction (b)**
	(Inchoative) Intransitive	**Transitive (Causative)**
Alternating	The ball rolled	The man rolled the ball
(a) only	The man laughed Do you want to see our heads disappear? I don't want any more grapes; I'll cough I (didn't) giggle(d) Will I climb up there? Did it bleed? I always sweat [when I wear it] [They're nice enough that] I wish I had one	*The clown laughed the man ***Do you want to see us disappear our heads? (6;0)** ***I don't want any more grapes; they just cough me (2;8)** ***Don't giggle me (3;0)** ***Will you climb me up there (3;2)** ***Did she bleed it? (3;6)** ***It always sweats me** ***[They're nice] enough to wish me that I had one (5;8)**
	Prepositional-object (PO) dative	**Double-object (DO dative)**
Alternating	The boy gave a present to the girl	The boy gave the girl a present
(a) only	The boy dragged the box to the girl The boy suggested the trip to the girl I said no to her Shall I whisper something to you?	*The boy dragged the girl the box *The boy suggested the girl the trip ***I said her no (3;1)** ***Shall I whisper you something? (7;8)**
	Contents (figure) locative	**Container (ground) locative**
Alternating	The boy sprayed paint onto the statue	The boy sprayed the statue with paint
(a) only	The boy poured water into the cup Mommy, I poured water onto you I don't want it because I spilled orange juice onto it	*The boy poured the cup with water ***Mommy, I poured you [M: You poured me?] Yeah, with water (2;11)** ***I don't want it because I spilled it of orange juice (4;11)**
(b) only	*The boy filled water into the cup ***I'm gonna cover a screen over me (4;5)** ***Can I fill some salt into the bear [-shaped salt shaker]? (5;0)**	The boy filled the cup with water I'm going to cover myself with a screen Can I fill the bear with salt?

Taiwan Southern Min,[57] Inuktitut,[58] and Quechua.[59] Further (English) examples of these errors and of analogous errors involving the dative and locative constructions are given in Box 1. Explaining how children retreat from these errors has proved a very difficult challenge for language acquisition researchers, given that there is generally no single form that straightforwardly pre-empts or blocks the error (as, for example, *went* for **goed*).

Adult Recasts

Although adults very rarely provide *direct negative evidence* that a particular form is incorrect (e.g., 'Don't say "cover a screen over me"'), they often provide *positive evidence* of possible grammatical uses (e.g., producing the correct form—'I covered myself with a screen'). This positive evidence constitutes a type of *indirect negative evidence*—evidence that alternative formulations are not permitted (formalized below as pre-emption/entrenchment). Particularly helpful are adult recasts, which express the child's intended meaning using a grammatical form. The following example[60] is typical (note that the child shows some evidence of accepting the recast).

Abe (2;5.7): the plant didn't cried.

Father: the plant cried?

Abe: no.

Father: oh. the plant didn't cry

Abe: uh-huh. [Kuczaj, Abe 3:163]

Although many studies[60–72] have shown that children selectively modify their utterances in response to recasts in this way, it would seem unlikely that they are sufficient to explain the retreat from error. The evidence summarized below indicates that children reject as ungrammatical certain uses of very low frequency and even novel verbs (in the latter case, based on their semantics), for which they cannot have received recasts during childhood.

Pre-emption

One possible solution is to broaden the notion of pre-emption outlined above with respect to errors at the single-word level (e.g., *deflate* blocking **unblow*). For example, a pre-empting alternative to a transitive-causative overgeneralization error such as **The magician disappeared the rabbit* would be *The magician made the rabbit disappear* (a periphrastic causative construction):

> Once one linguistic form for expressing a meaning has been learned, it pre-empts other forms that express the same meaning, unless the language input offers positive evidence for a second form (Ref 73, p. 360).

> Preemption is a particular type of indirect negative evidence that results from repeatedly hearing a formulation, B, in a context where one might have expected to hear a semantically and pragmatically related alternative formulation, A. Given this type of input, speakers implicitly recognize that B is the appropriate formulation in such a context, and that A is not appropriate (Ref 74, p. 60).

There is some debate in the literature regarding exactly what counts as 'a context where one might have expected to hear a[n]. . .alternative formulation' (e.g., see Ref 75, especially p. 134–135, Refs 76 and 77). Essentially, however, the prediction that follows from this account is that the greater the token frequency of a particular verb in a particular construction in the input (e.g., *disappear* in the periphrastic causative; *X made Y disappear*), the less likely children will be to produce the corresponding error, where the verb appears in a semantically related construction in which it is, in fact, prohibited (e.g., **X disappeared Y*).

Two elicited production studies[78,79] have provided support for this prediction for children aged 4–5 and above. Children were taught a novel verb presented in intransitive sentences (e.g., *The car is tamming*). A pre-emption group also heard this verb used in periphrastic causative sentences (e.g., *The mouse is making the car tam*). As predicted, this group was more reluctant than a control group to generalize this verb into the transitive-causative construction (e.g., **The mouse is tamming the car*). However, the use of a production task is not ideal here, as it is impossible to rule out the possibility that children in the pre-emption group produced fewer overgeneralizations than the control group simply because they produced more periphrastic causative sentences (children generally produced only one response per trial). That is, the 'pre-emption' training may have simply increased the rate of production of periphrastic causatives, but had no bearing on the perceived acceptability of transitive causatives.

Two recent studies addressed this problem by using a grammaticality judgment methodology with children (aged 5–6 and 9–10 years) and adults, across a large number of verbs ($N = 301$ and $N = 142$). A regression methodology was used to allow for investigation of the unique contribution of pre-emption above and beyond other predictors. Findings were mixed with the pre-emption measure explaining a unique proportion of variance for overgeneralization errors involving the dative constructions,[80] but not the locative constructions.[81] Further research—for example on the transitive-causative construction—is needed to clarify whether the effect of pre-emption genuinely differs across constructions, or whether this pattern is due to methodological differences between the two studies (e.g., the different numbers of verbs used). In addition to the *un-* prefixation judgment study discussed above,[20] a further production study[74] found evidence for pre-emption in the domain of a-adjectives (e.g., **the asleep boy* is pre-empted by *the boy who is asleep*). This study avoided the methodological problems associated with the transitive-causative studies discussed above[78,79] by testing generalization to novel items, though it was conducted on adults, and has not yet been extended to children.

In summary, the balance of evidence suggests that pre-emption plays an important role in the retreat from overgeneralization. However, as for parental feedback, pre-emption is unlikely to be sufficient, as it cannot explain the finding outlined below that adults and children rate certain uses of novel verbs as ungrammatical (apparently on the basis of their semantics), despite having heard no potentially pre-empting uses.

Entrenchment

In common with pre-emption, the concept of *entrenchment* originates in the domain of morphological overgeneralizations, but has been extended—and slightly altered—to encompass overgeneralizations of verb argument structure. As it is generally understood in

this domain, the claim of the entrenchment hypothesis is that every attested token of a particular verb—regardless of construction—contributes to an ever strengthening probabilistic inference that unattested uses are ungrammatical ('otherwise I would have heard it by now') (note that, like pre-emption, entrenchment is sensitive to token, as opposed to type, frequency). The difference between pre-emption and entrenchment can be illustrated by considering the example overgeneralization error **The magician disappeared the rabbit*. Pre-emption occurs only when this verb appears in the single most-nearly-synonymous construction: the periphrastic causative (e.g., *The magician made the rabbit disappear*). Entrenchment occurs when this verb appears in *any* construction, or even as the sole element of an utterance (e.g., *He disappeared; Would you like me to disappear?; Disappear!*). Thus, in principle, pre-emption (corpus frequency in a single construction) and entrenchment (overall corpus frequency) can be dissociated in experimental designs, though only a handful of studies have attempted to do so.[20,76,79–81] Entrenchment/pre-emption effects (again the two are rarely dissociated) are often observed in Bayesian and connectionist models of language acquisition.[82–90]

The prediction that follows from the entrenchment hypothesis is that, holding other factors constant, overgeneralization errors with higher frequency verbs (e.g., **The magician disappeared the rabbit*) will be both (1) less likely to be produced and (2) rated as less acceptable than equivalent errors with lower frequency verbs (e.g., **The magician vanished the rabbit*). There is a great deal of support for this prediction from production and judgment studies, both those using familiar English verbs[20,76,80,81,91–97] and those that have manipulated frequency experimentally using novel verbs[98] or—in one case—nouns in a novel particle construction.[99] These findings extend across all the construction types studied (see Box 1) and, indeed, novel constructions invented for the purposes of the experiment.[99,100]

That said, very few of these studies have attempted to dissociate entrenchment and pre-emption and—to our knowledge—of those that have attempted to do so,[20,76,79–81] only three have done so by statistically partialling out the effect of one on the other. All three were conducted on children aged 5–6 and 9–10 years, and adults. Entrenchment was found to have a dissociable effect beyond pre-emption for errors involving *un-* prefixation (for the older two groups) and the locative constructions (for all three groups), but not the dative constructions (for any group, though the raw entrenchment measure was nevertheless a significant predictor of participants' judgments at all ages). One possibility is that this is due to methodological differences between the studies. Indeed, the fact that the pre-emption and entrenchment measures are so highly correlated makes it difficult to obtain reliable estimates of the unique contribution of each. A more interesting possibility is that the balance between pre-emption and entrenchment differs according to the particular generalization in question, and may depend on the relative frequency of the verb in potentially entrenching versus potentially pre-empting constructions. For example, potentially pre-empting verb uses are presumably relatively more common for the dative constructions (where PO- and DO-dative uses pre-empt one another) than transitive-causative overgeneralizations (where pre-emption occurs only via the rare periphrastic causative construction). Indeed, as one leading proponent of the pre-emption hypothesis has pointed out,[74,75] entrenchment alone incorrectly predicts that frequent verbs should be entirely unavailable for use in unattested constructions, which does not seem to be the case (e.g., 'I actually had a moth go up my nose once. I . . . coughed him out of my mouth'; p. 132).

More generally, many recent studies in other domains of language acquisition have provided further support for the role of probabilistic surface-based statistical/distributional learning—of which pre-emption and entrenchment are specialized instances—in forming and constraining generalizations. Perhaps, the most celebrated example is an 8-month-old infants' use of transitional probabilities between syllable pairs to discover word boundaries.[101] At the level of syntax, a number of researchers have attempted to demonstrate that probabilistic statistical learning can obviate the need for innate constraints posited to solve apparent learnability problems. While evaluation of this specific claim is well beyond the scope of this article, here we present three examples of cases where statistical learning seems to be at least part of the story, whether or not additional innate constraints turn out to be necessary. With regard to *structure dependence*,[102] two computational modeling studies[103,104] demonstrated that a surface-based distributional learner can predict the structure of complex questions (e.g., *Is the boy who is smoking crazy?*) with a relatively high degree of accuracy and, like children,[105,106] generally avoid structure-dependence errors (e.g., **Is the boy who smoking is crazy?*). With regard to *subjacency*, a similar model[107] was able to learn the structure of well-formed questions (e.g., *What did Sara hear that everybody likes?*), but not questions such as (e.g., **What did Sara hear the news that everybody likes?*), which, under traditional accounts,[108,109] are ruled out

by innate knowledge of subjacency, a grammatical principle of which the model had no in-built knowledge. Finally, one recent study[110] demonstrated that a Bayesian statistical learner could, in principle, learn to choose the correct interpretation of anaphoric *one*. The phenomenon is that when shown, for example, 'a yellow bottle' and asked to 'find another one', children as young as 1;6 correctly interpret *one* as referring to 'yellow bottle' (i.e., the phrasal category N') and not simply to 'bottle'.[111,112] Interestingly, the model succeeds by doing something very close to pre-emption/entrenchment: noting the *absence* of the co-occurrence of strings (here, *one*) and referents (here, bottles that are not yellow) that would be predicted by the over-general rule (here, that 'one' can mean both yellow and non-yellow bottles). Although the findings of a more recent study suggest that this learner succeeds only because it incorporates innate knowledge in the form of a filter on the evidence that it considers,[113] even researchers who advocate the nativist position agree that statistical learning also plays an important role (e.g., see Ref 111, p. B72).

In short, a fair conclusion is probably that both surface-based statistical learning more generally and pre-emption/entrenchment in particular play a role in the formation and restriction of linguistic generalizations. However, it is almost certainly the case that such learning mechanisms are not sufficient to explain the phenomenon. This is because these mechanisms generally fail to include a role for semantics (and, as a consequence, struggle to explain why participants consider certain uses of novel verbs to be unacceptable). However, as the evidence reviewed below suggests, semantics seems to play a crucial role in the retreat from overgeneralization.

Verb Semantics

The semantic verb class hypothesis[114] starts from the observation that verbs' argument-structure privileges are not arbitrary. Rather, verbs that may and may not appear in particular constructions cluster into groups of verbs with similar semantic properties. The relevant semantic properties are, themselves, non-arbitrary, having to do with the semantics of the construction. For example, the transitive-causative construction is associated with the meaning of direct, external, prototypically physical causation (e.g., *John broke the window*). Evidence for this claim is the observation that the use of this construction to describe rather indirect acts of causation (e.g., an event where John distracts a passerby, causing him to walk into the window and accidentally smash it) is somewhat infelicitous. Consequently, verbs that exhibit these semantic properties (e.g., verbs of 'change of state' such as *open, close*, and *break*) form classes that may appear in the transitive-causative construction. On the other hand, verbs that denote 'volitional or internally caused actions' (Ref 114, p. 131) such as 'coming into or going out of existence' (e.g., *disappear, vanish*) and 'semi-voluntary emotional expression' (e.g., *laugh, giggle*) form classes that may not.

Under the semantic verb class hypothesis,[114] children produce errors such as **I disappeared it* or **Don't giggle me* when they have acquired the general semantics of the construction (or 'broad-range rule'), but have yet to hone the fine-grained narrow-range semantic classes of verbs that may and may not appear in that construction. The prediction that follows from this hypothesis is that if children are tested at this second stage, they should reject transitive-causative uses of novel verbs that are semantically consistent with intransitive-only classes (e.g., novel verbs meaning to *laugh* or *disappear* in a particular manner). This prediction was confirmed for 5- to 6-year-olds, 9- to 10-year-olds, and adults in two recent studies.[95,96] A follow-up study[93] demonstrated (1) that this effect is observed even when no familiar English verbs (which could provide clues to correct usage) are included in the study and (2) that children also accept transitive-causative uses of novel verbs from alternating classes (e.g., similar in meaning to *bounce/roll* or *break/smash*), indicating that they are not simply rejecting transitive-causative sentences across the board. Both of these findings were also observed for children aged 4;5 and above (though not a younger group aged 2;5) in an analogous elicited production study.[78] Two further judgment studies extended these findings to overgeneralization errors involving the (1) locative[115] and (2) dative[94] constructions, although only for (1) the two older groups (9–10 and adults) and (2) adults, respectively.

A finding common to all of these studies is that participants are more tolerant of overgeneralizations involving some non-alternating verb classes than others. For example, all age groups rated overgeneralizations of verbs of 'semi-voluntary emotional expression'—both familiar and novel—(e.g., **The funny clown laughed/giggled/meeked Lisa*) as more unacceptable than overgeneralizations of verbs of 'going out of existence' (e.g., **The magician disappeared/vanished/tammed Lisa*). We have argued elsewhere[81,95,96] that this finding is problematic for an account under which verbs are assigned to discrete intransitive-only or alternating classes.

A possible solution is to replace the notion of discrete semantic classes with something more probabilistic. One possibility is that, as suggested above with regard to *un-* prefixation, learners are

acquiring constructions whose slots probabilistically exhibit particular semantic properties. For example, the (VERB) slot in the transitive-causative construction [(SUBJ) (VERB) (OBJ)] exhibits properties associated with direct, external, prototypically physical causation. If this is the case, then if it is possible to obtain ratings of the extent to which verbs exhibit the semantic properties relevant to the (VERB) slot of particular constructions, these ratings should predict the acceptability of the sentence that results when each verb is used in that construction. This prediction has not yet been tested with regard to the transitive-causative construction (though see Ref 95 for some preliminary support). It does, however, enjoy support from studies of the dative and locative constructions, which are associated with the following (approximately described) semantics:

Prepositional-object (PO) dative	**Double-object (DO) dative**
X causes Y to go to Z (literally or metaphorically)	X causes Z to possess Y (literally or metaphorically)
e.g., *John sent a package to Chicago (c.f., *John sent Chicago the package)*	e.g., *The noise gave Sue a headache (c.f., *The noise gave a headache to Sue)*
Figure (content) locative	**Ground (container) locative**
X causes Y to move into/onto Z	X causes Z to undergo a state change as a result of Y moving into/onto it
e.g., *John poured water into the cup (c.f., *John poured the cup with water)*	e.g., *John filled the cup with water (c.f., *John filled water into the cup)*

Accordingly, in both studies, ratings of the extent to which verbs were rated as exhibiting these semantic properties were a significant predictor of the relative (un)grammaticality of particular verb uses. This finding held for all three age groups studied (5–6 years, 9–10 years, and adults), even after controlling for effects of pre-emption and entrenchment. By virtue of its probabilistic nature, such an account draws no line in the sand between 'true overgeneralizations' and more acceptable 'coercions' that are attested in the adult language (e.g., 'Did you loot me something?', an example provided by a reviewer who raised this issue). This is in fact a desirable feature, as participants' acceptability judgments in the studies discussed are finely graded in exactly this way.

We should acknowledge that, as pointed out by a (different) reviewer, our focus on verbs as slot fillers represents a significant departure from the more traditional (and perhaps prevailing) view within linguistics that syntax is projected from verbs in accordance with their valency requirements. However, we would suggest both (1) that it is difficulty to see how a valency-based approach could explain the results outlined above and (2) that there are sound theoretical arguments against such an approach (e.g., it requires positing a three-argument lexical entry for *sneeze* in order to account for the acceptability of *He sneezed the napkin off the table*; Ref 116).

Slots with Complex Properties

For the majority of cases discussed so far, the relevant properties of particular (VERB) slots have been either wholly semantic or wholly phonological in nature. In some cases, however, the compatibility of a particular item with a particular slot reflects a complex combination of factors, hence necessitating probabilistic acquisition mechanisms that can incorporate roles for competing factors. Indeed, with regard to the (VERB) slot in the dative construction, these factors reflect both the learner's previous experience with the construction and—indirectly—the history of the language itself. As discussed above, the (VERB) slot in the two dative constructions—PO and DO—exhibits subtly different semantic properties (roughly, caused motion versus caused possession). They also differ with regard to properties that have been described as morphophonological in nature.[117,118] It has long been noted that, even when semantically compatible, verbs that are of Latinate origin are restricted to the PO-dative construction, with DO-datives ungrammatical (e.g., *John suggested the trip to Sue; *John suggested Sue the trip*). The claim is not that speakers are sensitive to etymology *per se*. Latinate verbs can be identified by their stress pattern [disyllabic with second-syllable stress (e.g., *suggest*) or trisyllabic (*contribute*)] and perhaps by their use of certain morphemes (e.g., *-ify*, *-ate*), whereas native Germanic verbs are mostly monosyllabic (e.g., *give, tell*) or have first-syllable stress. Within the present framework, this can be captured by positing that the (VERB) slot in the DO-dative probabilistically exhibits these properties (i.e., monosyllabicity, first-syllable stress), such that a less than fully grammatical utterance results when a verb that does not exhibit these properties is used in the slot (e.g., **John suggested Sue the trip; *John donated the library the book*). Although there has been some scepticism in the literature with regard to this proposed morphophonological constraint,[119] three studies have shown that adults (but not yet children)

respect this constraint in judgment and production studies, even when taught novel pseudo-Latinate verbs.[80,94,120] Relatedly, the findings of one recent study suggest that the adjective slot in the adjectival construction (ADJECTIVE) (NP) exhibits properties that could be described as morphophonological (or perhaps etymological) and rejects incompatible adjectives. The restriction is that the filler of the adjective slot must not be segmentable into *a-* plus a related stem (e.g., the *scared/astute/*alive/*afraid man*) and, again, adult learners respect this restriction even with novel adjectives[74] (though pre-emption also seems to be at work here).

The information that is conveyed by verb argument structure (word order) in the English examples above (i.e., who did what to whom) is instead, in many languages, conveyed by rich systems of inflectional morphology (e.g., case marking on nouns and person/number marking on verbs). Nevertheless, the general mechanisms outlined in this review would seem to be applicable to languages and linguistic systems that are—on the surface—very different to the case of English verb argument structure: Again, probabilistic statistical learning operating over interacting distributional, morphophonological, and semantic properties can explain how learners constrain their generalizations. One well-studied example of such a system is gender marking in languages such as Russian, Serbian, and Lithuanian. In all three languages, 2- to 3-year-old children produce incorrect gender marking errors at rates of 20–30% in less transparent parts of the system (e.g., for novel feminine nouns in Russian[121] and Serbian[122] and novel masculine nouns in Lithuanian[123]). To learn the system, children must observe probabilistic partial regularities at the level of distribution (e.g., nouns often appear after agreeing adjectives), morphophonology (e.g., feminine nouns generally end in *–a*, as opposed to a consonant), and semantics [e.g., masculine nouns usually refer to males and feminine nouns to females, though words that refer to males (e.g., uncle) are sometimes declined as feminine and vice versa]. As all are partial regularities, as opposed to hard and fast rules, some kind of probabilistic generalization mechanism working at the levels of distribution, morphophonology, and semantics simultaneously is really the only conceivable solution. Indeed, we would suggest that if the investigation of the formation and restriction of generalizations had begun with such systems instead of—for example—the English past-tense, single-mechanism accounts such as the *dual-route model* would never have got off the ground.

CONCLUSION

This review has summarized theoretical proposals and empirical evidence regarding the retreat from overgeneralization with regard to (1) word learning [e.g., **doggie* (for *bear*)], (2) morphology [e.g., **spyer* (for *spy*), **unsqueeze, *goed*], and (3) verb argument structure (e.g., **Don't giggle me*). Across the domains, four factors seem to be particularly important.

- *Conventionality*: Children understand from an early age that a speech community shares conventions regarding the 'right' way to express particular meanings, and are motivated to acquire and respect these conventions. Conventionality is not so much a mechanism for the retreat from error in the sense that contrast/pre-emption, entrenchment, and fit are, more a necessary pre-condition that motivates children to respect adult conventions in the first place.
- *Contrast/Pre-emption*: Different forms—some attested, some potential generalizations—compete for the right to express the speaker's intended message. This is seen in all three domains. For example, (1) *bear* pre-empts *doggie*, the child's over-general form for this referent, (2) *went* pre-empts **goed*, and (3) the periphrastic causative (e.g., *The magician made the rabbit disappear*) pre-empts transitive-causative overgeneralizations (e.g., **The magician disappeared the rabbit*).
- *Entrenchment*: Even occurrences of items that do not contribute to pre-emption (e.g., *disappear* in constructions other than the periphrastic causative) contribute to a probabilistic inference from absence. The more often a verb is encountered without ever appearing in a particular construction, the stronger the inference that its use in this construction is ungrammatical. Although much work remains to be done in this regard, when pre-emption and entrenchment are dissociated experimentally, both generally make some contribution, though the relative importance of each varies from study to study and construction to construction.
- *Fit*: A potential generalization is grammatical to the extent that the properties of the potential slot filler (most often a verb) overlap with those of the slot. This is true for morphological constructions [*un-*(VERB); (VERB)-*ed*] and verb argument-structure constructions such as the transitive causative [(SUBJ) (VERB) (OBJ)]. The relevant properties may be morphophonological (as for

the past-tense constructions), semantic (as for the transitive-causative and locative constructions), or some combination thereof (as for the English DO-dative construction and Slavic/Baltic gender systems).

There are two further potentially relevant factors that have received rather less attention. The first is the overall frequency of each competing construction.[76] It would seem likely that, all other factors being equal, frequent constructions such as the transitive causative will enjoy an advantage over less frequent constructions such as the periphrastic causative in the process by which constructions compete to express the speaker's intended message. The second is the extent to which each construction is relevant to the speaker's communicative goals. For example, *The rabbit disappeared* is a perfectly grammatical description of an event where a magician causes a rabbit to disappear, but may lose out in the construction-competition process to **The magician disappeared the rabbit* because this better expresses the speaker's intended meaning.

Theoretical work on integrating all of these factors into a complete cross-domain account of the retreat from overgeneralization has barely begun (for some preliminary attempts, see Refs 17, 20, 80, 81, and 94). Because such an account will necessarily incorporate a number of interacting factors, it will probably be best instantiated and tested as a computational model (for some attempts along these lines, see Refs 86, 90, and 124–128[b]).

In the meantime, the empirical evidence summarized in this review suggests that a complete account of the retreat from overgeneralization errors in the domains of word learning, morphology, and syntax will include roles for at least the factors of conventionality, contrast/pre-emption, entrenchment, and semantic/phonological fit. It is to be hoped that future research will elucidate the relative contributions of these factors, and so bring us closer to a complete understanding of the capacity for restricted generalization that is characteristic of human languages.

NOTES

[a]Such accounts do allow for rote storage of some regulars.

[b]A reviewer asked whether mechanisms such as preemption, entrenchment, and verb semantics might combine to yield U-shaped learning of verb argument structure, as observed in the domain of past-tense learning. Again, answering this type of question will almost certainly require a computational model of the relevant phenomenon. However, it is important to note that macro U-shaped learning—where overall error rates are low, then increase, then fall again—is probably a myth.[129] Although some verbs may show an apparent error-free early period, a more common scenario is that correct forms and errors coexist, with the former gradually winning out over the latter.[42]

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FURTHER READING

Many of the articles cited in the review section can be downloaded from the first author's website at http://pcwww.liv.ac.uk/~ambridge/ which also hosts example stimuli from a number of the studies reviewed.

