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Grammatical categories and the nature-nurture debate

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Abstract The linguistic mainstream typically describes first-language acquistion as a process involving innate species- and domain-specific abilities. Such accounts of syntactic development conceive the primary linguistic input as too limited for language acquisition to take place. The present paper discusses word categorization skills and strategies in small children. Recent empirical evidence shows that very young English-learning children are able to extract salient phonological features of words in their language and use them for accurate word categorization. In addition to this, young children also appear to use statistical regularities from fluent speech in order to group grammatically similar words together. Of special importance to these findings are the observations made by studies analyzing categorization outside the linguistic domain and/or the human species. Crucially, these findings note that not only linguistic input is probabilistic in nature. The upshot of these studies is that the ability to deal with probabilistically sequenced elements is neither (a) domain-specific, since it also applies to other domains of human perception and cognition, nor (b) is it species-specific, since this skill has also been found in some bird species and primates like cotton-top tamarins.

Keywords: word categorization, child-directed speech, statistical learning, phonological cues, domain-specificity, species-specificity.

1. Introduction

Current theories in evolutionary biology describe structures that aid a given organism as either inherited or specific adaptations. Inherited adaptations are said to derive from the organism's ancestors. Such traits are general in two important ways: first, many species share them (i.e. they are not species-specific) and, second, they serve relatively general purposes (i.e. they are not domain-specific). Specific adaptations, on the other hand, may have suited the organism's specific needs (KELLY & MARTIN 1994: 105; SEE ALSO DEACON, 1998; TOMASELLO, 1999).

As for human beings, some of the cognitive, perceptual and motor skills that we possess, or the biological structures that underlie them, have certainly been inherited from our ancestors. Thus, such behavioural competences are shared across different species (e.g. *bipedalism*, the ability to walk on our legs). By contrast, other faculties might be unique to our own evolutionary history. Over the years, mainstream linguists have claimed that language is one such faculty. Our ability for speech and grammar has been described as both species-specific, in the sense that it is unique to human beings, and domain-specific, since linguistic competence is seen as independent from other systems of human perception and cognition (CHOMSKY 1975).

Under such accounts, learning is accomplished by mechanisms which are particular to the domain in question. Thus, for linguistic nativists, language learning is a task which involves mechanisms that are specific to language and that only human beings possess.

In particular, nativists claim that language acquisition is accomplished by means of an innate capacity or *language faculty*. The initial state of the language faculty is called *Universal Grammar* (UG). It is defined as a set of parametric grammatical principles common to all natural languages. Since most parameters are generally binary in nature, they allow for very little variation and ban children from considering an infinite number of hypotheses during the process of language development. Given such a framework, much, if not most, of what we know of our own language is claimed to be part of our genetic endowment and, therefore, present at birth, rather than inductively learned from observation of the language around us.

The present paper undertakes a critical examination of such a view. The main argument is that an important part of the language acquisition problem must involve learning from the environment. Specifically, this paper focuses on children's ability to classify words in their correct grammatical category. The word categorization problem must be solved, at least in part, by an interaction between children's learning mechanisms and the particular language input the child is exposed to. This paper will explore both the possibilities that children's linguistic input offers for word categorization as well as the powerful learning mechanisms that learners have, which might ultimately enable them to extract the relevant information they need from their linguistic exposure and might yield accurate word categorization. Finally, we shall explore whether these learning mechanisms which are used for such a basic grammatical task are indeed domain- and species-specific, or whether they correspond to more general adaptations.

2. Linguistic nativism and grammatical categories

One of the most difficult issues within the nature-nurture debate is to actually figure out what exactly is innate and what is learned. Exposure to any form of natural language during the first years of life is doubtlessly essential for language acquisition to take place. Besides, everybody would agree with the fact that human beings are somehow biologically prepared to acquire a natural language. The problem is then how to identify the exact nature of this preparation and whether or not the ability to acquire a language involves the inheritance of specific linguistic structures.

Arguments for a general kind of linguistic nativism assume that what is innate about language is the manner and the procedures by which we process linguistic information. According to this view, human beings are assumed to have innate learning mechanisms which are unique and specific to language. Such mechanisms are, therefore, independent from other cognitive operations and procedures.

Other arguments, however, assume linguistic nativism not only regarding the learning mechanisms that are involved in the acquisition of natural languages, but also regarding the categories and the structures to be learned (CHOMSKY 1965; 1981 CRAIN & LILLO-MARTIN 1999). Not only that, but they further assume that the essence of language is grammar, which is understood as being completely independent from other levels of linguistic analysis as well as from other cognitive systems (MARANTZ 1995; NEWMEYER 1998).

Hence, it is easily assumed that, on the one hand, grammar is independent from the rest of linguistic domains (i.e. from phonology, the lexicon, pragmatics, etc.) and, on

the other hand, that grammar is innate and part of our phylogenetic inheritance (CHOMSKY 1965). Thus, within this representational innateness approach, the innate linguistic module does not contain things like innate learning mechanisms specific to language, but it includes actual grammatical content and structure.

One of the problems about theories of representational innateness is that they are very vague in their descriptions of what this innate grammar consists of, what exactly belongs to UG, or even the number and the kind of parameters which govern linguistic structure and which are part of our genetic endowment. In one of the few detailed descriptions of what constitutes UG, O'Grady (1997) provides a list of syntactic categories (i.e. both lexical and functional categories) which are understood as core elements of what is assumed to be part of human beings' innate grammatical knowledge.

One of the most prevalent arguments for linguistic nativism is the so-called *Poverty of the Stimulus Argument* (ANDERSON & LIGHTFOOT 2002; CHOMSKY 1993; CRAIN & PIETROSKI 2001; LAURENCE & MARGOLIS 2001; 2002; PINKER 1994). According to this argument, the samples of linguistic data to which children are exposed during their first years of life are too impoverished and inconsistent, and the core aspects of grammatical structure that need to be acquired are only scarcely represented. Therefore, given the fact that language development cannot be accomplished with such impoverished linguistic representations, and that the input alone cannot account for all the linguistic aspects that need to be mastered, it follows that children must be born with innate *a priori* grammatical structure that might guide their processing of linguistic information and ultimately make language development a feasible task to complete.

One of the main problems regarding language universals and the binary nature of most grammatical elements within generative grammar is that they do not account for the linguistic diversity found across different natural languages. Thus, for example, regarding primitive lexical categories, which are claimed to be innate, the framework assumes that all natural languages have such things as verbs, adjectives or nouns. If this is true, then it follows that word classes are part of our innate grammatical knowledge. Furthermore, within nativist lines of argumentation, word classes must also be necessarily innate, given that with the limited linguistic experience to which children are exposed, it is impossible for them to build grammatical categories on the basis of experience alone.

3. "Poverty of the stimulus" arguments

As has been previously described, nativist accounts on language acquisition claim that the input to which language learning infants are exposed to cannot be the source of core aspects of linguistic knowledge. Language is essentially unlearnable and, therefore, it must be a kind of human instinct (ANDERSON & LIGHTFOOT 1999; 2002). The claim that children's linguistic knowledge results from a specific innate capacity rather than from inductive observation of their linguistic input is supported by the fact that children have been shown to know things that they could not have learned from observation or any plausible teaching. Nevertheless, recent studies that analyze child-directed speech in depth have provided evidence that suggest that the linguistic envirnonment to which children are exposed has been underestimated. Thus, for instance, findings from studies of neural activity suggest that one-year-old infants attend more to child-directed speech than to adult-directed speech. This suggests that child-directed speech acts as an indicator of potentially meaningful

streams of speech and it triggers brain activity in very young infants (ZANGL & MILLS 2007). Child-directed speech has also been shown to facilitate language-related tasks such as word segmentation (THIESSEN & SAFFRAN 2003).
Nativist accounts of language acquisition as far as word categorization is concerned hold the view that knowledge about grammatical categories is innately specified. Such a view is based on the assumption that there is insufficient evidence in the child's language environment to enable these properties to be learned from the input. However, one cannot deny the informativeness of the linguistic input without exploring its potentials to its limits, and several studies have already pointed out the problems of assuming an impoverished stimulus beforehand (e.g FEIJÓO 2007; PULLUM 1996; PULLUM & SCHOLZ 2002; SAMPSON 2002; SCHOLZ & PULLUM 2002; SCHOLZ & PULLUM 2006).
If children's innate endowment includes not only the necessary procedures to discover the basic grammatical categories that are realized in their language, but also the relevant cues which signal grammatical category membership, such cues should be universally valid across languages. However, it is very unlikely that there exists such set of universal cues for grammatical categorization common to all natural languages.
Thus, children must be able to identify that some properties of words actually correlate with word classes, that is, that words can be grouped in grammatical categories and, depending on the category to which they belong, they can enter into particular grammatical relationships and perform certain syntactic functions. What is more, children should be able to identify such properties from the linguistic samples to which they are exposed. The following section provides a review of the kind of cues which, being sufficiently represented in the input might yield accurate categorization of linguistic elements.

4. The availability of cues for grammatical categorization

Any approach which describes a learning model based on cues must consider the validity of such cues (i.e. their availability and reliability in the input), as well as the strength of those cues and the cost of processing them (KAIL 2000). Studies of cues that are effective in identifying the grammatical category of words have focused on properties that are either internal or external to words. External properties are those that determine the use or function of the word from its context (i.e. distributional or semantic information). In contrast, effective information for the same purpose can also be found within the word itself. Such internal cues include phonological or prosodic information. In what follows, I will revise the role of both internal and external cues as far as English word categorization is concerned.

4.1. Phonological cues

Young language learning infants have no access to word meaning, especially prelinguistic infants at the first stages of development. Provided we assume no innate grammatical endowment, young language learners will have no initial access to grammar either. Thus, during the onset of the language learning process, phonological cues are the only ones from which young infants might start building a linguistic system.

A number of studies have already provided evidence for the usefulness of phonological information as a key element for the access to grammatical properties of language (e.g. BROOKS ET AL. 1993; CASSIDY & KELLY 1991; 2001; CUTLER 1993; JUSCZYK 2001; PETERS 1997). So, phonological cues might also be a useful source to help children determine the distinctions between grammatical categories.

A range of phonological cues have been proposed in the literature to correspond to particular syntactic categories in English. On the one hand, some of the proposed cues are related to distinguishing open class words (i.e. nouns, verbs, adjectives, etc.) from closed class words (i.e. prepositions, determiners, conjunctions, etc.). Such an initial broad categorization might help children establish a distinction between lexical items and function words (MONAGHAN, CHRISTIANSEN & CHATER 2007; MONAGHAN, CHATER & CHRISTIANSEN 2005; MORGAN, SHI & ALLOPENNA 1996). This might help them further categorize lexical items in further subcategories more accurately. In English, among the cues that have been said to be relevant in the open *versus* closed class word distinction, the following are the most significant ones (MONAGHAN, CHATER & CHRISTIANSEN 2005):

- *Word and syllable duration*: open class words tend to be longer and have longer syllables than closed class words. Closed class words, on the other hand, tend to be acoustically minimal, although they occur with very high frequency. Furthermore, the status of function words as free morphemes is often weakened: they can become cliticized or shortened, and therefore, they may lose syllabicity.

- *Consonant clusters*: open class words are more likely than closed class words to contain consonant clusters. In fact, the inventory of consonant phonemes found in function words is much smaller than that found in content words.

- *Vowel quality*: closed class words are more likely to contain centralized vowels than open class words. Furthermore, these centralized vowels are often reduced to *schwa*. On the other hand, open class words tend to have full low or high vowels.

- *Consonant position*: closed class words are less likely than open class words to contain consonants in word onsets. Even if they do, the kind of consonants that closed class words have in word onset position are different from the ones in open class words (e.g. /ð/ only occurs word-initially in closed class words in English).

Additionally, some other phonological cues have been found to be relevant to distinguish some open class words from others in English (KELLY 1992, 1996; MONAGHAN, CHATER & CHRISTIANSEN 2005; MONAGHAN, CHRISTIANSEN & CHATER 2007). Furthermore, empirical studies reveal that young language learners as well as adults are aware of such cues and their correlation to grammatical categories (CASSIDY & KELLY 2001; FARMER, CHRISTIANSEN & MONAGHAN 2006; FITNEVA, CHRISTIANSEN & MONAGHAN 2009; KELLY & BOCK 1988; MONAGHAN, CHATER & CHRISTIANSEN 2003). Among the set of proposed cues for English, the following are the most relevant ones:

- *Stress*: in English, disyllabic nouns tend to be stressed on the first syllable, while disyllabic verbs tend to be stressed on the last syllable.

- *Syllables*: nouns contain more syllables than verbs in English. Experimental evidence suggests that trisyllabic linguistic units are typically associated with nouns, while monosyllabic linguistic units are associated with verbs (CASSIDY & KELLY 1991). Furthermore, children seem to be aware of that difference in vocabulary acquisition (CASSIDY & KELLY 2001) The superiority of nouns compared to verbs as far as length is concerned has also been found at other levels within the word. Thus, controlling for syllable number, nouns tend to contain more phonemes than verbs (KELLY 1996; MONAGHAN, CHATER & CHRISTIANSEN 2005).

- *Vowel height and quality*: in English, nouns tend to have more low vowels, while verbs tend to have more high vowels (KELLY 1996; MONAGHAN, CHATER & CHRISTIANSEN 2005). Besides, vowels in nouns tend to be back, whereas vowels in verbs tend to be front (SORENO & JONGMAN 1990).

- *Consonant quality*: nouns are more likely than verbs to have nasal consonants in English. Furthermore, if a word finishes in a consonant, it is more likely to be voiced if the word is a noun rather than a verb.

The literature suggests that, taken individually, each phonological cue is not very powerful on its own, in the sense that each cue alone does not successfully categorize a significant sample of words. However, taken together, they yield an accurate and successful word categorization. Thus, provided the constellation of cues outlined above is available in the input, it will significantly reflect the overall phonological shape of broad grammatical categories.
Furthermore, as initial broad categorization and analysis proceeds, the child will be able to deal with smaller linguistic samples to be analyzed, where correlations between cues and categories might be stronger. Besides, as their development proceeds, learners will be able to cope with other sources of information in combination with phonology.

4.2. Distributional cues

Distributional information might also be a powerful cue for word categorization. Thus, the context of a word with respect to other words in the same sentence might provide indications about the category of that word in English. For example, English nouns are typically preceded by determiners and followed by nominal morphology, while verbs are typically preceded by auxiliaries or strong subject pronouns and followed by verbal morphology. In this way, a determiner like *the* will be a high predictor of a nominal element (as in the phrase *the baby*) while other words like *have* will not.
Thus, as Mintz (2003) proposed, distributional information of the kind that can be found in the co-occurrence of patterns of words in sentences could provide a great deal of information relevant to the grammatical categories to which words belong.

Such distributional information appears to be available not only to adult speakers but also to young language learners (GERKEN 1996; GERKEN, WILSON & LEWIS 2005; MINTZ 2002; MINTZ ET AL. 2002; SAFFRAN, ASLIN & NEWPORT 1996; SAFFRAN, NEWPORT & ASLIN 1996; WAXMAN & BOOTH 2001).

Within nativist frameworks, researchers claim that unconstrained distributional analyses of a language cannot lead to the correct grammatical rules of that language. One of the potential problems that a learner who relies on distributional information is likely to encounter is that of non-immediate adjacency. As noted by some authors (e.g. CHOMSKY 1965; PINKER 1987), distributional regularities in English are not always local, but can occur over a variable distance. Patterns of lexical adjacency are variable in English. Thus, in the case of nouns and determiner-noun adjacencies, there can be a variable number of intervening modifying elements between the determiner and the noun. A learner who relies on strictly local distributional information and categorizes only from fixed positions could get to the wrong generalization that, for instance, *lovely* in '*the lovely dog*' is a noun, and not an adjective. How does the learner know which environments are important and which should be ignored?

Another potential difficulty of distributional analyses of the input comes from the fact that some words in English can be both nouns and verbs, and their distributional contexts will vary accordingly. As suggested by Pinker (1987), those words will also give rise to incorrect inferences on the part of the language learner who relies on distributional information as the only source of information for grammatical categorization. Consider the following examples:

(1) *Laurie wants some help*.
(2) *Laurie wants some chocolate*.
(3) *Laurie could help*.
(4) **Laurie could chocolate*.

Language learners who rely on distributional information would incorrectly categorize *help* and *chocolate* together and, after being exposed to examples as the one in (3), they would incorrectly assume that (4) is also possible. Thus, English words which belong to more than one category will also occur in different syntactic contexts, providing misleading information to language learners. Pinker (1987) argued that the resulting wrong generalizations would be common, and would make it impossible to accurately categorize words on the basis of distributional information alone.

However, despite these potential problems, empirical studies that analyze actual child-directed speech have shown that in children's input, neither dual-class words nor non-local adjacencies undermine the informativeness of distributional patterns (MINTZ ET AL. 2002; REDINGTON, CHATER & FINCH 1998). Although problematic environments may exist, there is nevertheless enough evidence for accurate categorization in child-directed speech, compared to the noise created by the problematic environments. Thus, although such problematic environments exist, it seems that they are just not frequent enough to rule out the possibility of categorizing words from distributional contexts completely.

In general terms, then, categorizing words in child-directed speech on the basis of their distributional context produces extremely accurate categories. Thus, the efficiency of distributional contexts, and the relative simplicity and accessibility of the information they provide for categorization make them very good candidates for

young language learners with very little linguistic experience as well as limited memory and processing resources. Thus, distributional information might be a viable ground from which children undertake word categorization tasks (MARATSOS 1998).

4.3. The combination of cues in the linguistic environment

Multiple cues which are available in the input can contribute to the development of accurate grammatical categories. As seen above, distributional and phonological cues might reveal the grammatical category to which words belong with a certain degree of accuracy on an individual basis. More interestingly, if taken together, combined cues might still yield a greater accuracy in grammatical category assignments.

Monaghan, Chater & Christiansen (2005) as well as Monaghan, Christiansen & Chater (2007) have analyzed the correlation between phonological and distributional cues in the input. The analyses show that, when combined, phonological and distributional cues interact in such a way that they provide useful, and perhaps sufficient, information for the development of grammatical categories. They propose the so-called *Phonological-Distributional Coherence Hypothesis*. Its main claim is that, when distributional information is present for the categorization of a certain word, the phonological cues of that word will be less crucial and, therefore, some shifting of these cues can occur. However, when distributional information is weaker for any given word, then the phonological cues to the accurate categorization of that word will be stronger. Thus, they predict a perfect coherence between both types of cues: when one source of information is weaker at assigning category membership, then the other type of cues will be stronger (MONAGHAN, CHRISTIANSEN & CHATER 2007).

In an analysis of English child-directed speech corpora, Monaghan, Chater & Christiansen (2005) found support for the *Phonological-Distributional Coherence Hypothesis*: both phonological cues and distributional cues were found to be accurate to determine the grammatical category membership of words. Furthermore, accuracy in categorization increased when both types of cues were combined. Not only that, but they also showed that the improvement when considering cues in combination was due to the fact that words which were miscategorized by one type of cue tended to be accurately categorized by the other type of cue. Thus, phonological and distributional cues contributed to the categorization of words in a different way.

Furthermore, Monaghan, Christiansen & Chater (2007) provide evidence that the *Phonological-Distributional Coherence Hypothesis* might also be true for other languages. In their analysis of English, Dutch, French and Japanese child-directed speech corpora, the same interaction between phonological and distributional cues was found, suggesting that the role of the different cue types might be general across very different languages. Therefore, these studies demonstrate the wealth of the language learners' linguistic environment, as well as the benefit of integration of information from multiple sources.

5. Species- and domain-general learning abilities

As stated before, proponents of representational innateness within the generative grammar approach suggest that the core aspects of the grammatical structure of all natural languages are part of what they label as *Universal Grammar*. Such a view

entails two main assumptions. First, the architecture of syntax is generally represented in terms of rules, and it is understood as being autonomous and independent from phonology and the lexicon. Second, the set of rules that make up the syntactic structure of natural languages is claimed to be universal (i.e. common to all linguistic systems) and innately specified, given the fact that these rules could not possibly be learned from experience, mainly because grammatical features are underrepresented in speakers' output.

The present paper provides evidence against both assumptions. To start with, syntactic aspects of language might not be completely independent from phonology or the lexicon. The empirical evidence revised here provides compelling evidence that phonological and distributional information contribute to a great extent to a very basic syntactic procedure, namely the grammatical categorization of English words.

Furthermore, nativist approaches also claim that the core aspects of grammatical structure of natural languages (i.e. those aspects which belong to *Universal Grammar*) are innate, since it is impossible to learn them on the basis of the impoverished input that constitutes children's linguistic environment. If there is something universal at all within all existing natural languages, this must be the fact that all languages have nominal elements. Thus, the grammatical category of noun is probably the best candidate for children's presumably existing genetic endowment. If so, and if the *Argument of the Poverty of the Stimulus* were right, then the set of features that make up the noun category as a whole should be underrepresented in parental speech addressed to children. However, the empirical evidence reviewed in the present paper suggests that grammatical categories can, in fact, be learned from input-driven data without the need of postulating any *a priori* innately specified linguistic knowledge about their nature.

Consequently, if there is anything innate at all in the development of grammatical categories, it must be the kind of learning mechanisms that allow children to process, benefit from and deal with the kind of linguistic cues that are present in the input and which make up the set of defining criteria for nouns. Nativist accounts of linguistic skills outside representational innateness approaches claim that, although actual grammatical categories and structure might be learned, they are learned by innate mechanisms which, as such, are both domain-specific and species-specific. Thus, as stated in the introduction, the main claim under these assumptions is that language learning is mainly accomplished by means of mechanisms which are exclusively devoted to the linguistic domain and are uniquely found among the human species (CHOMSKY 1975; FODOR 1983; LENNEBERG 1967).

However, empirical evidence from research does not provide support for such a claim either. As mentioned before, from the very early stages of language development children already exhibit statistical learning abilities as well as sensitivity to phonological features. Such skills allow children to exploit the linguistic cues in the input for grammatical categorization purposes. If such learning mechanisms are innate, then they must be unique of the linguistic domain on the one hand and of the human species on the other hand.

Nevertheless, a number of studies provide evidence that such learning mechanisms are used by children in tasks other than language learning and, furthermore, they are used at the same stages of cognitive development, parallel to the language learning tasks (BATES 1994; SAFFRAN 2002; SAFFRAN & THIESSEN 2007). For example, empirical research on cognitive development show that learning in such different domains as both music and language is, at least in part, subserved by the same domain-general learning processes or mechanisms (MCMULLEN &

SAFFRAN 2004; SAFFRAN ET AL. 1999). Similar results have been found when comparing linguistic skills with domain-general cognitive skills using visual stimuli (FISER & ASLIN 2001; KIRKHAM, SLEMMER & JOHNSON 2002; YOUNGER 1993).

What is more, similar learning mechanisms have been found not to be specifically human. In particular, when nonhuman primates (e.g. cotton-top tamarin monkeys) are tested using similar procedures, they show the same statistical learning abilities as human infants (HAUSER ET AL. 2002; HAUSER, NEWPORT & ASLIN 2001; RAMUS ET AL. 2000). Bonobos have been shown to possess impressive word recognition skills as well (SHANKER, SAVAGE-RUMBAUGH & TAYLOR 1999). Furthermore, sensitivity to phonological cues and prosodic patterns which parallel human abilities have also been found among other species, like rats (TORO, TROBALON & SEBASTIÁN-GALLÉS 2005), or chinchillas (KUHL & MILLER 1975).

Thus, animals might possess far more sophisticated learning abilities than were previously hypothesized. Therefore, human infants are not a privileged species neither at computing transitional probabilities of sequential units in language, nor at detecting linguistic prosodic regularities. On the contrary, the kind of learning mechanisms which are needed to perform one of the fundamental tasks within language development, namely word categorization, does not seem to be domain- or species-dependent. Therefore, an important component of linguistic development does not seem to have its roots in any kind of biological adaptation, which entails that grammar might not be, after all, the product of human phylogeny. Consequently, the phylogenetic components of human linguistic abilities should be reconsidered.

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