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From shared contexts to syntactic categories: The role of distributional information in learning linguistic form-classes

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ABSTRACT

A fundamental component of language acquisition involves organizing words into grammatical categories. Previous literature has suggested a number of ways in which this categorization task might be accomplished. Here we ask whether the patterning of the words in a corpus of linguistic input (*distributional information*) is sufficient, along with a small set of learning biases, to extract these underlying structural categories. In a series of experiments, we show that learners can acquire linguistic form-classes, generalizing from instances of the distributional contexts of individual words in the exposure set to the full range of contexts for all the words in the set. Crucially, we explore how several specific distributional variables enable learners to form a category of lexical items and generalize to novel words, yet also allow for exceptions that maintain lexical specificity. We suggest that learners are sensitive to the *contexts* of individual words, the *overlaps* among contexts across words, the non-overlap of contexts (or *systematic gaps* in information), and the *size* of the exposure set. We also ask how learners determine the category membership of a new word for which there is very sparse contextual information. We find that, when there are strong category cues and robust category learning of other words, adults readily generalize the distributional properties of the learned category to a new word that shares just one context with the other category members. However, as the distributional cues regarding the category become sparser and contain more consistent gaps, learners show more conservatism in generalizing distributional properties to the novel word. Taken together, these results show that learners are highly systematic

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in their use of the distributional properties of the input corpus, using them in a principled way to determine when to generalize and when to preserve lexical specificity.

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1. Introduction

The ability to categorize is a powerful mechanism that learners employ to represent and interact with their environment. Categories compress information, thereby reducing demands on memory, and they allow for rapid generalizations. There are many fewer categories than exemplars, and if a particular exemplar is a member of a category, it inherits the defining properties of category membership. Often these defining properties are based on perceptual similarity (things that are green), semantic relations (things that float), or functional roles (things that can be sat upon). In the domain of language, however, there is a very loose relationship between perceptual, semantic, or functional properties and grammatical categories. A noun that serves as the subject of a sentence does not always sound like other subjects, express uniform semantics, or even play the same role in sentences that convey the same meaning (e.g., The *frog* ate the bug vs. The *bug* was eaten by the frog).

How, then, do naïve learners master the assignment of exemplars to grammatical categories in natural language? This is a crucial first step in language acquisition, since sentences of languages are organized in terms of grammatical form-classes (such as noun, verb, and adjective). Language learners must determine when they should treat words as a category (thus generalizing from properties of experienced words to novel words) and when they should treat words separately, as lexically idiosyncratic (with no generalization from properties of experienced words to novel words). Importantly, words of both types do in fact occur in natural languages. This process of organizing words into categories, and the selective generalization of patterns from experienced word combinations to novel ones, account for important aspects of the expansion of linguistic knowledge in the early stages of language acquisition. As highlighted above, linguistic categories are rarely defined on the basis of perceptual similarity; assignment of words to most grammatical categories is independent of the surface features of its members.

There are a number of additional complicating factors that make the acquisition of grammatical categories different from non-linguistic categorization. We hear individual words in a limited number of specific contexts. However, the rules that languages are built on involve patterns defined over *categories* of words, not the individual words themselves. Additionally, language input is serially presented – we hear words in their various sentence contexts spread out over hours or days – so learners continually need to predict the proper contexts for words they have not yet heard in their full range of possible contexts. Learners never see the entire input corpus, so they must figure out the proper contexts for new words, keeping in mind that sometimes there are lexically specific restrictions on words (such as *give* versus *donate*: despite having similar meanings, Joe can *give David a book*, but Joe cannot **donate David a book*). In acquiring grammatical categories, then, the learner must tease apart lexically specific restrictions and small-sample omissions from the corpus, asking whether contexts are absent by accident or because they are ungrammatical.

This question is particularly difficult to resolve when a new item is encountered in a single context and therefore only minimally overlaps with previously encountered words. For example, consider hearing the sentence: *I remembered to nerk yesterday*. Should one generalize from this context to other contexts that are grammatical for the category 'verb', such as *She will make him nerk tomorrow*, or *I saw the cat nerk earlier*?

Despite the difficulty of this problem, learners are able to determine how to use a new word even when there is very sparse information regarding its acceptable contexts. A number of hypotheses have been considered to explain this (Gleitman & Wanner, 1982). One hypothesis regarding how learners solve the problem of categorization is that linguistic categories (though not their lexical instantiations) are innately specified prior to experiencing any linguistic input, with the assignment of tokens to categories accomplished with minimal exposure (e.g., Chomsky, 1965; McNeill, 1966). However,

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