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Word Learning in a Domestic Dog: Evidence for "Fast Mapping"

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steroids in asthma may be mediated, in part, by their ability to increase pH and decrease AMCase bioactivity. In combination with studies highlighting the expression of the chitinase-like proteins, YM-1 and YM-2 (*18*) and AMCase (*19*) in animal models, these studies emphasize the potential importance of chitinases as mediators of Th2 responses. The present studies also suggest that AMCase is a potential therapeutic target that can be manipulated to control asthma and other forms of IL-13– or Th2-mediated pathology.

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Word Learning in a Domestic Dog: Evidence for "Fast Mapping"

Juliane Kaminski, Josep Call, Julia Fischer*

During speech acquisition, children form quick and rough hypotheses about the meaning of a new word after only a single exposure—a process dubbed "fast mapping." Here we provide evidence that a border collie, Rico, is able to fast map. Rico knew the labels of over 200 different items. He inferred the names of novel items by exclusion learning and correctly retrieved those items right away as well as 4 weeks after the initial exposure. Fast mapping thus appears to be mediated by general learning and memory mechanisms also found in other animals and not by a language acquisition device that is special to humans.

The rate at which most toddlers acquire their vocabulary is astounding: From about 2 years of age, typical English-speaking children incorporate about 10 new words per day into their vocabulary until they reach an average vocabulary size of 60,000 words by the time they graduate from high school (*1*). Several studies have shown that children have a set of operating principles that guide the task of word learning (*2–4*). However, it remains a matter of debate which of these principles are unique to language learning and which are more general cognitive abilities that may be shared with other living creatures. We investigated the outer limits of a domestic dog's "word learning"; that is, his ability to acquire the relation between a word and the object that this word refers to (the referent). By studying his retrieval behavior with familiar and novel items, we specifically tested whether he would be able to infer the referent of a new word by exclusion learning: that is, to "fast map" (*5–7*) and retain this knowledge over time.

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The study animal, Rico, is a border collie and was born in December 1994. He lives as a pet with his owners and was reported by them to know the labels of over 200 items, mostly children's toys and balls, which he correctly retrieved upon request. Rico was first introduced to fetching items when he was 10 months of age, when his owners placed three different items in different locations around the flat and asked the dog for one of these items. Rico was rewarded with food or play if he fetched the correct object. He was gradually familiarized with an increasing number of items. Typically, the owners introduced new items by presenting them and saying their name two or three times. Rico then got the chance to play with the new item, and it was subsequently integrated into the collection of other items.

However, it remained unclear whether a "Clever Hans" (*8*) effect might account for his performance. The first experiment was therefore designed to assess Rico's ability to correctly retrieve his various items under controlled conditions. We randomly assigned the 200 items he was reportedly familiar with to 20 sets of 10 different items each. While the owner waited with the dog in a separate room, the experimenter arranged a set of items in the experimental room and then joined the owner and the dog. Next, the experimenter instructed the owner to request the dog to bring two randomly chosen items (one after the other) from the adjacent room (*9*). While Rico searched for the requested item, he could not see the owner or the experimenter. He retrieved a total of 37 out of 40 items correctly (binomial test, $P < 0.001$). This experiment showed that Rico indeed knew the labels of these items. One may raise the objection that the words may in fact constitute one-word propositions, such as "fetch-the-sock." However, anecdotal evidence suggests that he indeed understands that the words refer to the objects. For instance, he can be instructed to put an item into a box or to bring it to a certain person. More systematic testing will be needed to specify his understanding of entire phrases. In any case, the number of labeled objects is substantially larger than those reported in previous studies with dogs, where subjects were tested with only three to five objects (*10*, *11*). Rico's "vocabulary size" is comparable to that of language-trained apes, dolphins, sea lions, and parrots (*12*).

To assess Rico's ability to fast map, we placed a novel item together with seven familiar items in an adjacent room (total $n = 8$ items requested in 8 trials). In this so-called identification task, we conducted a total of 10 sessions in which we introduced 10 novel items. In the first trial of a session, the owner always asked Rico to bring a familiar item, and in the second or third trial asked him to bring an item using the novel name (*9*). After the completion of a session, Rico was allowed to take a break before another session commenced. Rico retrieved the novel item from the first session on and was overall correct in 7 out of 10 sessions (binomial test, $P < 0.001$). Apparently, he was able to link the novel word to the novel item based on exclusion learning, either because he knew that the familiar items already had names or because they were not novel. Four weeks after the initial and sole exposure, we as-

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sessed Rico's retention of the relation between the novel word and the novel item. In this retention task, we only used those objects that Rico had successfully retrieved in the identification task. In between the identification and the retention task, he had no access to the target items. We placed a target item together with four completely novel and four familiar items in a room (total $n = 9$ items) and asked him first to bring a familiar item and subsequently (in the second or third trial) to bring the target item. Four weeks after the identification task, he correctly retrieved the target item in 3 out of 6 sessions ($P < 0.1$). This retrieval rate is comparable to the performance of 3-year-old toddlers (*1*, *5*). In the other cases, he brought one of the unfamiliar items and never one of the familiar items. We then replicated the experiment, first conducting a new set of identification tasks using novel items. When he was tested for retention of the novel word-object combinations 10 min after the identification task, he correctly retrieved the target item in 4 out of 6 trials ($P < 0.02$).

These experiments demonstrate that Rico reliably associates arbitrary acoustic patterns (human words) with specific items in his environment. Apparently, Rico's extensive experience with acquiring the names of objects allowed him to establish the rule that things can have names. Consequently, he was able to deduce the referent of a new word on the basis of the principle of exclusion when presented with a novel item along with a set of familiar items (*13*, *14*). This corresponds to the acquisition of the novel-name–nameless category principle (*3*) and also to the avoidance of lexical overlap described in children (*4*). Moreover, Rico was able to store this knowledge about the link between word and object in memory, because he was able to correctly retrieve the target item from a set of novel and familiar items both immediately after introduction of the novel word-object combination and 4 weeks later.

It remains a matter for further empirical investigation whether Rico's accomplishments are based on an exceptional mind or a result of his extensive exposure to many word-object combinations. Undoubtedly, he is a highly motivated dog, and some of his talent may be accounted for by the fact that border collies are working dogs (*15*). More generally, dogs appear to have been evolutionarily selected for attending to the communicative intentions of humans (*16*–*18*). Nevertheless, we assume that Rico's performance can be decomposed into a set of simpler mechanisms. These consist of (i) his acquisition of the principle that objects have labels; (ii) a general learning mechanism, namely learning by exclusion (emergent matching) (*19*); and (iii) the ability to store that knowledge in memory. Therefore, our results strongly support the view that a seemingly complex linguistic skill previously described only in human children may be mediated by simpler cognitive building blocks that are also present in another species. Whether Rico's ability to form a link between a label and an object is homologous to children's knowledge about the names of things remains a matter for further investigation. Clearly, from early on, toddlers have a much broader knowledge than Rico about the meaning of words, and they can distinguish between different functions of words such as verbs, adjectives, and proper nouns. Moreover, children are able to use their newly acquired knowledge productively; that is, they are able to say the words whose meaning they have identified through fast mapping. Nonetheless, our findings corroborate the assumption that listeners' ability to attach meaning to specific sounds evolved much earlier than, and independently from, a flexible production of specific sound patterns (*20*). That is, some of the perceptual and cognitive mechanisms that may mediate the comprehension of speech were already in place before early humans began to talk (*21*, *22*).

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