Tall is Typical: Central Tendency, Ideal Dimensions and Graded Category Structure Among Tree Experts and Novices

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Abstract

Many accounts of categorization equate goodness-of-example with central tendency for common taxonomic categories; the best examples of a category are average members, i.e., those that are most similar to most other category members. In the present paper, we asked 24 tree experts and 20 novices to rate goodness-of-example for a sample of 48 trees, and found, a) that the internal structure of the category tree differs between novices and experts, and b) that central tendency did not determine goodness of example ratings for either group. For novices, familiarity determined goodness of example ratings. For experts, the "ideal" dimensions of height and weediness, rather than average similarity to other trees, were the primary predictors of goodness of example ratings for experts. The best examples of tree were not species of average height, but of extreme height. The worst examples were the weediest trees. We also found systematic differences in predictors of goodness of example as a function of type of expertise. We argue that the internal structure of taxonomic categories can be shaped by goal-related experience and is not necessarily a reflection of the attributional structure of the environment. Implications for models of category structure and category learning are discussed.

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All members of a category are not equal. Rather, categories exhibit graded structure, in which some members are better representatives of the category than others. For example, for American undergraduates robins are considered to be better members of the category bird than penguins, and Labrador retrievers are better members of the category dog than poodles. Graded structure seems to be a universal property of categories. It has been shown to exist in common taxonomic categories (e.g., Rosch & Mervis, 1975; Smith, Shoben, & Rips, 1974), abstract categories (Hampton, 1981), goal-derived categories like things to eat on a diet (Barsalou, 1985), ad hoc categories like things that could fall on your head (Barsalou, 1983), and even formal categories like odd number and square (Armstrong, Gleitman, & Gleitman, 1983).

How representative an exemplar is of its category (the typicality of the exemplar) turns out to have an important influence upon many cognitive tasks. For example, participants are faster at verifying the category membership of a typical exemplar than an atypical exemplar (McCloskey & Glucksberg, 1979; Smith, 1978); for instance, people are faster at saying that a robin is a bird than a penguin is a bird. Typical exemplars are more likely to be generated in category-listing tasks (Barsalou, 1983, 1985; Mervis, Catlin, & Rosch, 1976). Typical category members are learned faster than atypical category members (Mervis & Pani, 1980; Rosch, Simpson, & Miller, 1976). The typicality of a category member also affects its inductive potential (Osherson, Smith, Wilkie, López, & Shafir, 1990; Rips, 1975); people are more likely to think that all members of a category share a novel property attributed to a typical member of the category than to an atypical member of the category.

Thus, graded structure is an aspect of concept representation that any model of categorization must address. Not surprisingly, a fair amount of research has been devoted to understanding the determinants of the graded structure of categories. By far the most popular view is that typicality is driven by central tendency--an example is typical to the extent that it is similar to fellow category members and not similar to members of alternative categories. Similarity-based models of categorization provide a natural account of typicality based on central tendency. Rosch and Mervis (1975) showed that an exemplar was rated a better example of a category to the extent that it was similar to other category members and dissimilar to non-category members. Using feature listings for natural superordinate and basic categories, they showed that category exemplars which had more listed features in common with other category members were also rated as the most typical. In two experiments with artificial categories Rosch and Mervis again showed that exemplars which shared more features with other category members and fewer with non-category members were rated as more typical of the category. These typical examples were also easier to learn and quicker to be identified after learning.

Organizing categories around central tendencies facilitates the general function of categorization: to reflect and emphasize the uneven distribution of attributes in the environment. As Rosch and Mervis (1975) put it:

> ...if natural categories of concrete objects tend to become organized so as to render the categories maximally discriminable from each other, it follows that the maximum possible cue validity of items within each category will be attained...The principle of family resemblance relationships [central tendency] can be restated in terms of cue validity since the attributes most distributed among members of a category and least distributed among members of contrasting categories are, by definition, the most valid cues to membership in the category in question. (p. 575).

Thus, the notion of central tendency as the determinant of graded structure is attractive because it is based upon the same principles that can be used to explain category learning. That is, both the internal and external structure of categories serve to maximize within-category similarity and between-category distance.

But central tendency does not determine the graded structure of all categories. Barsalou (1985) found that central tendency was the major determinant of the graded structure of taxonomic categories, but played no role in the graded structure of goal-derived categories, such as clothes to wear in the snow. Rather, the graded structure of goal-derived categories was organized around ideals. For instance, exemplars are better members of the category clothes to wear in the snow to the extent that they keep people warmer. The best example of this category (down jacket) is not the exemplar that is most like other category members; rather, it is the exemplar with the most extreme value on the goal-related dimension. The better the exemplar serves the goal of the category, the more typical is the exemplar of the category.

Trait categories also have an internal structure organized around goals or ideals, rather than central tendency. Borkeneau (1990) showed that both the typicality of acts for traits and the similarity between acts and traits, and among acts and among traits, was higher to the extent to which the items shared extreme values on dimensions of the similarity space. Similarly, Read, Jones, and Miller (1990) showed that both the similarity and typicality ratings of behaviors can be predicted by the extent to which the behaviors acheive the same goal. Chaplin, John, and Goldberg (1988) also found that the typicality of traits and states was organized around ideals, or extreme values on attribute dimensions.

In sum, research on typicality indicates that the determinants of typicality structure vary according to whether the category is goal-based or taxonomic. For goal-based categories, category members are more typical to the extent that they share extreme values on a goal-related dimension. For taxonomic categories, objects are more typical to the extent that they are similar to an average member of the category. However, Atran (in press) has observed that graded structure of taxonomic natural kind categories is determined on the basis of ideals for the Itzaj Maya of Peten, Guatemala. Using a set of 104 pictures of Central American birds, Atran compared direct ratings of which were "true" birds with central tendency ratings computed from average similarity derived from a sorting task. For Itzaj Maya and University of Michigan undergraduates, passeriformes (small perching birds, like sparrows) are high in central tendency. Americans also see passerines as ideal ("true") birds. Itzaj, however, nominated galliformes (turkeys) as ideal, despite their low central tendency ratings. The Itzaj say that the wild turkey is a '"true" bird because it has tasty meat and is extremely beautiful. Thus, for Americans, central tendency and ideals converged on the same birds; for the Itzaj, they did not.

This study raises the possibility that the amount or type of experience with category members can affect the internal structure of a category. That is, contrary to the suggestion of Rosch and Mervis (1975), the internal structure of taxonomic categories is not solely a reflection of the correlational structure of the environment. In this paper we test the possibility, raised by Atran (in press), that different kinds of experience with a taxonomic category can lead to differences in the determinants of typicality. To test this idea. we compared the graded structure of the category tree for three kinds of Chicago area tree professionals and a group of American college students. The three types of tree professionals are: taxonomists, landscapers, and parks maintenance personnel. We are interested in whether the determinants of the graded structure of the taxonomic category tree differ for novices who have seen millions of trees but have little goal-related experience with them, and for tree experts, a population that has salient goals in relation to the category as well as extensive experience with its attributional structure. Further, we are interested in whether the different types of goals that characterize our three groups of tree experts will differentially effect graded structure.

We know from our previous research on experts' categorization and reasoning about trees (Medin, Lynch, Coley & Atran, 1997) that experts organize their knowledge about trees along both goal-related and morphological dimensions. The distribution of goal-related and taxonomic groupings varied systematically across our expert groups. The predominant type of grouping across experts was not goal-related, but taxonomic (or morphological). The landscapers displayed the greatest number of goal-related groupings on a free sorting task, while the taxonomists displayed no goal-related groupings and the maintenance workers primary goal-related grouping was weed trees. Weed trees was the most common non-taxonomic grouping among the experts in our free categorization (sorting) task.[1] The weediness of a tree is an impediment to a maintenance worker or landscaper who is trying to keep a neat and organized landscape. Weed trees tend to be fast-growing with weak wood and require high maintenance. In addition, the landscapers produced other goal-related groupings in the sorting task, such as street trees, shade trees, and ornamental trees.

The attributional structure of trees is available to our novice sample but they probably have virtually no goal-relevant experience with trees (except maybe climbing them as children). We assume that any knowledge that the novice group has about trees has been aquired passively.

In the current study we investigate whether goal-related experience affects the graded structure of the category tree by comparing novice and expert typicality ratings of trees. Further, including different types of experts enables us to compare the ways different types of experience affect graded structure. To answer these questions, we asked the novices and the three groups of tree experts to rate the extent to which they thought 48 tree species found in the Chicago area were good examples of the category tree. We then investigated the degree to which several possible predictors of tree typicality, including central tendency, familiarity, height (a potential ideal dimension), weediness (a goal-related dimension, and a potential "negative ideal"), and frequency actually predict these ratings.

As discussed above, central tendency is a measure of the average similarity of each tree to each other tree. We test central tendency measures derived from both the Medin et al. (1997) sorting task (which incorporates goal-relevant dimensions) and scientific central tendency, which measures the similarity of trees according to scientific classification. Trees that are prototypical by virtue of being similar to many other trees will tend to have high central tendency scores. We also tested the goal-related dimension of weediness. As discussed above, trees that exhibit any of a cluster of undesirable properties can be considered weed trees. Our previous work suggests that this is the most salient of a set of functional, goal-related dimensions that may be present in experts' tree classifications (Medin et al., 1997). Thus, to the degree that such considerations influence graded category structure, any tree species that exhibits these undesirable properties might be considered a poorer example of tree. Additionally, the frequency with which a category instance occurs has been shown to be related to perceived typicality (e.g., Barsalou, 1985; see also Boster, 1988). Another variable that we thought might influence goodness of example ratings, especially for the novices, is familiarity (Malt and Smith, 1982; Worthen and Nakamura, 1995). Finally, post hoc observations suggested that the characteristic height of a tree species had a strong influence on its representativeness.

If, as previous research has shown, overall attributional structure is the major determinant of the graded structure of taxonomic categories, with goals only peripherally affecting category structure, we expect central tendency to be the major predictor of rated typicality for both novices and experts. On the other hand, experience may render goal-related attributes like weediness salient enough to override central tendency as the structural basis of even taxonomic categories. Because the tree experts in this study are highly knowledgeable about both the attributional structure of the category tree and its many functional roles, they are an excellent population with which to determine both the role of perceptual attributes on the graded structure of a taxonomic category and the extent to which goals can affect graded structure.

Method

Participants

Our participants were 24 tree experts from the Chicago area and 20 Northwestern University undergraduates participating for class credit. The tree experts ranged in age from 27 to 69, and work mainly with trees in their primary occupations. Our sample consisted of three types of tree experts: taxonomists working mainly in research and education (n=5), landscapers who focus on placing trees in appropriate settings (n=9), and parks maintenance personnel who plant new trees, prune, treat disease, and remove dead or dying trees (n=10).

All expert participants were involved in a larger, long-term study of categorization and reasoning among tree experts.

Materials

Two familiarity scales and a typicality scale were created using 48 tree species, listed in Table 1. There are approximately 80 species of trees native to the Chicago area and another 30 to 40 species have been introduced. After consulting with numerous reference sources and a few experts on local trees, we selected 48 tree species, including 29 native and 19 introduced species. The sample of 48 trees was biased toward the most common trees as indexed by a combination of city surveys of street trees and, in the case of native species, by the Swink and Wilhelm (1994) description of plants of the greater Chicago area. The set of 48 also included a few landscaping trees which would rarely if ever appear on city streets. The 48 trees were chosen to represent a broad spectrum of scientific taxa, and to include variations in patterns of folk nomenclature. Consensual patterns of sorting were used to establish separate measures of central tendency which were specific to each expert group (see Medin, et al., 1997).

Procedure

Goodness-of-example (GOE) ratings with respect to the category tree were collected from each participant for all 48 tree species. The instructions given to the participants in this study were identical to those used by Rosch and Mervis (1975). These instructions told the participants to rate how good an example each tree species was of the category tree on a seven-point scale, "1" representing a very good example of the category and "7" representing a very poor example of the category or not a member of the category.

Insert Table 1 about here

We also gathered familiarity ratings for the 48 tree species in two ways. Both familiarity scales asked the participant to rate the familiarity of each tree on a seven point scale, with 1 indicating very familiar and 7 indicating unfamiliar. The scales differed in their axis labels. One scale (ID familiarity), designed primarily for undergraduates, defined high familiarity as the ability to identify the tree (a 1 on the scale), while lack of familiarity meant they had never heard the name of the tree before (a 7 on the scale). This scale was completed by the full sample of undergraduates and a subset of the tree expert sample (n=19). The second scale was only completed by the subset of tree experts and measured familiarity with the trees in terms of how often they worked with each tree: a rating of 1 indicated that the participant worked with the tree very frequently and a 7 indicated that the participant worked with the tree rarely. The second scale was designed to better approximate familiarity among the experts, who were expected to be able to identify most of the trees.

Predictors of Goodness-of-Example

We used five predictors of typicality: central tendency, familiarity, weediness, height, and frequency. The values of these predictors for each tree species are given in Table 1.

Central tendency.[2] We measured central tendency in two ways. The expert central tendency and expert group specific central tendency measures came from the hierarchical sorting task of Medin et al. (1997). Twenty-four tree experts, including the entire sample used in the current study, performed a successive pile sorting task using name cards representing the same 48 trees used in the current experiment. Participants were asked to "put together the trees that go together by nature into as many groups as you like." After the initial sort, the participants were asked to successively group their initial piles of trees into higher level groups. Following the higher order grouping phase, the participants were invited to divide the original groups into subgroups. The participants were asked to explain their groups at each level.

The sorting task yielded a taxonomy of trees for each participant. We assume that the proximity of the trees in an individual's taxonomy represented the similarity of those trees for that individual. From these taxonomies we derived pairwise distances--as measured by the number of links that must be traversed in the hierarchy in order to reach a common link--between the 48 trees. The measure of central tendency used in this study is the standardized mean distance of each tree from every other tree averaged across all participants (overall expert central tendency) and averaged across expert subgroups (expert group specific central tendency). The Cultural Consensus Model (Romney, Weller & Batchelder, 1986) verified that there was consensus among the experts as to the similarities among the trees. (See Medin et al., 1997, for further details.)

Our second measure of central tendency was scientific central tendency--the pairwise distance of each tree from every other tree in the scientific taxonomy. The central tendency measures above incorporate experience derived goal-relevant information to some degree (except for the taxonomists, whose sorts correlate 0.97 with scientific taxonomy), and so may not be appropriate predictors of graded structure for novices. The scientific central tendency measure focuses upon overlap of attributes. Research has shown that scientific central tendency is a fairly good measure of similarity relations among biological organisms (Berlin, 1992; Boster, 1987, 1988; Malt, 1995). Scientific central tendency will serve as a measure of tree central tendency for the novices, for whom we do not have a direct measure of tree similarity.

Weediness. Our measure of weediness, like our measure of central tendency, is derived from the sorting task in Medin et al. (1997). For each tree we derived a weediness score by summing the number of times that it was placed in an explicitly identified weed tree category by an expert.[3] Although other goal-related groupings emerged for some of our experts (landscapers especially), frequencies were too low to serve as reliable predictors of typicality.

Height. Our measure of height was derived from a number of different field guides to Chicago-area trees (Dirr, 1978; Little, 1980; Petrides, 1988). Where a range was given for characteristic adult height, we used the midpoint and then averaged estimates across sources.

Frequency. To index frequency, we summed recent tree inventories from two Chicago-area municipalities (Evanston and Wilmette). These inventories are limited because they only count trees in the parkway (the area between the street and the sidewalk), and thus do not consider trees in parks or on private property, and because not all of our experts live or work in these areas. However, this measure provided at least a rough index of frequency-of-occurrence for each tree species in our sample. Because the populations for various species often differed by several orders of magnitude, we submitted these data to log transformations before entering them into the correlations reported below.

Results

Goodness of example (GOE) ratings were standardized for each participant to account for differences in their use of the 7-point scale. Table 1 presents rank GOE scores for experts and novices.

First, we will discuss raw and partial correlations of each of our variables with novice and expert average GOE ratings. Then we will compare predictors of GOE across our three expert subgroups.

Expert and Novice Correlations

Raw correlations are presented in the upper right-hand section of Table 2, which shows large differences in the predictors of novice and expert GOE ratings. Expert GOE ratings are highly correlated with all predictors except scientific central tendency while novice GOE ratings are highly correlated with Familiarity and mildly correlated with Expert Work Familiarity. Height accounts for the most variance in Expert GOE ratings with the other factors accounting for slightly less.

Insert Table 2 about here

Because of intercorrelations among predictors, second-order partial correlations were performed to assess the relation between GOE and each of the predictors with the other predictors held constant (following Barsalou, 1985). The second-order partial correlations for each group are shown in the first two columns of Table 2.

As can be seen in Table 2, when other factors are held constant, weediness and height explain much more variance in expert GOE ratings (59% and 54%, respectively) than central tendency (35%). The other factors do not predict a reliable amount of variance. Thus, for the expert group as a whole, though central tendency informs tree typicality to a significant extent, the graded structure of trees is primarily organized around the ideals of height and weediness. A multiple regression analysis confirmed the results of the partial correlations. When expert central tendency, weed, height, frequency, and the two familiarity measures are entered into the analysis the regression is reliable ($R=.83$, $R^2=.69$, $F = 15.4$, $p<.001$) with Expert CT, Height, and Weed as predictors. When expert central tendency is replaced by scientific central tendency the regression accounts for virtually the same amount of variance ($R=.82$, $R^2=.66$), but scientific central tendency does not emerge as a predictor. In fact, when central tendency is removed from the analysis the amount of variance accounted for remains about the same ($R=.81$, $R^2=.65$).

For novices, GOE ratings are accounted for almost entirely by familiarity. None of the other factors predict any reliable GOE rating variance. Again a multiple regression analysis was performed including scientific central tendency, weediness, frequency, height, and the novice familiarity measure. The regression was reliable ($R=.89$, $R^2=.79$, $F=31.6$, $p<.0001$) with only the familiarity measure as a reliable predictor.

<u>Differences in Perceived Typicality by Type of Expertise</u>

The previous analyses were based on GOE ratings averaged across all experts. We were interested in whether different types of professional experience (i.e. landscaping, tree maintenance, and taxonomy) would have differential effects upon the internal structure of tree. Thus, we analyzed determinants of typicality separately for each of our three tree professional subgroups. Table 3 shows the partial correlations for each expert subgroup, as defined by Medin, et.al (1997).

For the maintenance personnel weediness (r=-0.55), and to a lesser degree, folk central tendency (r=-0.31) predicted GOE ratings. All factors were entered into a multiple regression (R=.72, R^2=.52, F=7.33, p<.001) which confirmed that only weed and to a lesser extent folk central tendency were reliable predictors. The correlation between Maintenance worker and Landscaper GOE ratings was 0.75 and between Maintenance worker and Taxonomist, 0.76.

Landscapers and taxonomists exhibited a different pattern. For both groups, height (r_l=0.57, r_t=0.60) and weediness (r_l=-0.45, r_t=-0.50) predicted GOE ratings (see Table 3). Again, multiple regressions confirmed these partial correlations (Landscapers: R=.81, R^2=.66, F=13.02, p<.0001; Taxonomists: R=.79, R^2=.61, F=10.55, p<.0001).[4] The correlation between Landscaper and Taxonomist GOE rankings was 0.81.

Discussion

In this study we examined the extent to which familiarity, central tendency (both folk and scientific), frequency of occurrence, height, and perception of trees as "weeds" influenced goodness-of-example ratings collected from novices and three kinds of tree experts. We observed three major results. First, we found that different factors determine the internal structure of the category tree for novices and experts. Thus, we found an 'expertise effect' on typicality structure. These findings are consisten -cultural findings. Second, we found that, although 'tree' is a taxonomic category with a coherent and visible attributional structure, central tendency was not the primary determinant of graded structure for either novices or experts. Ideal dimensions--rather than central tendency--were primary determinants of graded category structure for experts. Third, we found that the determinants of graded structure varied among our expert subgroups. Below we discuss these findings in turn, and then consider their implications for models of category structure and acquisition.

Expertise effects on Graded Category Membership

We showed that the determinants of graded category membership differ for novices and experts. For novices, the extent to which they are familiar with a tree emerged as the sole determinant of its prototypicality. For experts, the story is more complicated. Overall, tree typicality is determined primarily by ideals on the dimensions of height and weediness and secondarily by folk central tendency. Thus, knowledge of trees appears to bring about a qualitative shift in the internal organization of the category.

Malt and Smith (1982) found that subjects tended to produce fewer properties for atypical words, indicating that atypicality may be determined in part by familiarity. However, they found that the relationship between familiarity and typicality may be due in part to a response bias in which subjects give words low typicality ratings because they are unfamiliar, rather than because they perceive the referent itself to be atypical of the category. Consistent with this, Worthen and Nakamura (1995) found that familiarity predicted typicality ratings better than central tendency for a low knowledge group while the two factors predicted typicality equally well for a higher knowledge group. These studies suggest that it is not level of familiarity in itself that determines novice tree GOE ratings. Rather, familiarity may be a marker of something else, say cultural significance, that more directly affects the graded structure of tree categories.

As a group the maples and oaks are the most typical trees for the novices. This is not surprising, and may be due to the prevalence in American culture of products deriving from the trees (i.e. Maple syrup, Oak floors and furniture). There are revealing cases which indicate that item familiarity is not the sole determinant of tree typicality. An interesting case is the Amur Maple of which few novices had ever heard (ranked 17 in familiarity) but which they ranked first in typicality, along with the other highly ranked maples. This may be related to the finding of Coley, et al. (1997) that novices assume that properties of trees cohere at the genus level (e.g. Maple), so that an unknown maple is bound to be very similar to better known maples.

Other interesting cases are the Weeping Willow which was ranked 1 in familiarity but only 13th in typicality, and the Sweet Crabapple which was quite familiar to the novices (ranked 8) but not very typical. These two cases suggest some influence of perceptual characteristics upon novice tree graded structure. Both trees are somewhat unique perceptually, the Weeping Willow with its hanging wispy branches, and the Sweet Crabapple with its flowers and small stature. In short, although these trees are relatively familiar, their distinctiveness makes them atypical examples of tree.

Given the above examples along with research suggesting that scientific central tendency is a good measure of naive similarity judgments among biological organisms (Berlin, 1992; Boster, 1987, 1988; Malt, 1995), it is interesting that scientific central tendency did not have any influence on the graded structure of the novice tree category. Perhaps if we had measured novice similarity directly (by showing them pictures) we would have found an influence of central tendency on typicality ratings. However, it is difficult to measure novice similarity of unfamiliar trees because trees are not easily represented visually. It is not clear what part of the tree should be in the photograph, and perhaps more importantly, tree form can vary dramatically as a function of environmental conditions.

In sum, the novice results are difficult to interpret because of their lack of familiarity with the domain. Interestingly, although trees are salient and ubiquitious objects, most people in our culture show a surprising lack of knowledge about them. Despite this lack of knowledge and the consequent difficulty in testing novices, trees are an interesting domain in which to study the effects of goals on taxonomic structure. Trees are natural, rather than constructed objects. They are not designed to achieve one particular goal, but are complex and linked to a variety of goals and knowledge structures in our expert population. The performance of our expert sample suggests some important ways that knowledge and goals might affect the internal structure of this complex category.

Ideals as Determinants of Graded Category Membership

This study is the first to demonstrate that ideals can serve as the primary determinants of the graded structure of a natural kind taxonomic category. While Barsalou (1985) found that ideals influenced the graded structure of both goal-derived and taxonomic categories, central tendency was always a stronger predictor for taxonomic categories. Our results, however, indicate that for experts, ideals are consistently the strongest predictor of GOE ratings for trees. That is, the most representative trees--those which are the best examples of the category tree--are not trees of average height, but rather trees of extraordinary height. Likewise, weediness served as a negative ideal for the experts. Thus, for the experts in our sample, tree appears to be structured around positive and negative ideal dimensions rather than the average of several relevant dimensions.

Weediness as negative ideal. Barsalou (1985) demonstrated that ideals for goal-derived categories are defined in terms of goals. Our finding raises the possibility that goals influence the graded structure of taxonomic categories as well. The negative ideal of weediness certainly fits this description. A tree is weedy to the extent that it causes problems for humans.[5] That is, from a maintenance standpoint, weed trees may have weak wood (and therefore drop branches), or may have large leaves, flowers or fruit which drop and clog gutters, stain sidewalks, and generally create a mess. Often weed trees grow easily from roots and therefore pop up where they are unwanted. For example, the Tree of Heaven, one of the most pernicious weed trees, grows everywhere, including cracks in sidewalks (as in A Tree Grows in Brooklyn). Rarely planted due to its weak wood which can be cut with a pocket knife, it is never considered a desirable tree (except, perhaps, in Brooklyn).

Barsalou (1985) claims that “ideals may often be determined independently of exemplars, being acquired through the process of planning how to achieve goals before exemplars are ever encountered” (p. 631). This explanation of ideals as being goal-related seems appropriate in the case of tree weediness. Some of our experts think of trees in terms of which kinds of trees can best fulfill some particular goal. For example, landscapers must satisfy a number of constraints when deciding what kind of tree to plant in a particular part of a landscape. Similarly, when deciding which plants to plant along the street of a city, it is important to plant trees that don’t interfere with electrical wires, are salt-tolerant (in Chicago at least), and are not too messy. Therefore, in the case of weediness, as Barsalou states above, the ideal may come before the exemplars.

Height as positive ideal. In contrast to weediness, it is not clear what expert goal is facilitated by tree height. One possibility is that increased height allows a tree to provide better shade. While plausible, shade does not seem to be a major concern of our tree experts. It has rarely been mentioned by our tree experts as a dimension of concern, hence it would be odd for it to play such a major role in organizing the tree category.

If height does not help tree experts achieve any goal, why is it height in particular which organizes the category tree? Organizing the category tree around the ideal of height may increase the distinctiveness of tree relative to other related categories (e.g, shrub, plant). Hunn (1986, 1989) suggests that tree differs from other high-level natural kind categories like bird and fish in that it is not defined in nature by a clear perceptual gap. That is, large trees fade imperceptibly into small trees which then fade into shrubs. We found, however, that the correlation between height and typicality is evident throughout the full range of heights and not simply near some presumed transition point between shrubs and trees. Still, the fact that height distinguishes trees from other plants may render it an essential, or defining dimension of ‘treeness.’

Thus, there are reasons why height in particular might be an ideal dimension and help to organize the concept tree. In general, however, we do not believe that tree is idiosyncratic in being a taxonomic category organized around ideals. Furthermore, the degree to which ideals organize taxonomic categories may increase with expertise. Atran (in press) argues that the Itzaj, who are familiar with Central American birds, organize bird categories around ideals, whereas U. S. undergraduates unfamiliar with these birds do not. Moreover, K. E. Johnson (personal communication, June 26, 1997) has also found evidence that American bird experts are influenced by ideal dimensions. Taken together, these findings hint that experts' categories may be organized

at more generally, taxonomic categories may be organized around ideals to a much larger degree than previously believed.

Expert Group Differences in Determinants of Typicality

The third interesting finding is that the experts were not uniform in the manner in which they organized their tree category. We found that the graded structure of "tree" for the maintenance workers was determined mainly by weediness and to a lesser extent folk central tendency. The taxonomists and the landscapers both organized their category tree around the ideal dimensions of height and weediness. These results are consistent with Medin et al. (1997) who show that the maintenance workers use the same organizational structure in two different tasks, whereas the landscapers use two different structures. That is, one could interpret the influence of folk central tendency on the graded structure of the maintenance worker tree category as a reflection of the same organizational structure that underlies the maintenance worker sorting and reasoning. The landscapers, on the other hand, used goal-derived dimensions on the sorting task (including weediness and size) but scientifically relevant dimensions to reason about novel tree properties. The current study shows that the internal structure of the landscapers tree category is organized around goal relevant dimensions. The taxonomists, like the landscapers, organize the structure of the tree category around the dimensions of weediness and height. Attentiveness to these dimensions by the taxonomists was not demonstrated on either of the Medin et al. (1997) tasks. Thus, the current study provides further evidence for the characterization of our expert groups whereby the maintenance workers rely on a single organizational structure across multiple tasks while the landscapers and this time, the taxonomists, employ different types of tree organization depending on the task.

Implications

We have shown that ideal dimensions may outweigh central tendency as determinants of graded category membership in common taxonomic categories. This finding has important implications for both models of categorization and for conceptual acquisition and development.

Similarity-based models of categorization frequently equate graded category membership, typicality, and central tendency. For example, in their investigations of the effect of typicality on category-based induction, Osherson et al. (1990) inferred typicality from participants' similarity judgments. They assumed that the categories with the highest central tendency were the most typical examples of the category. We have shown that for a diverse group of tree experts central tendency is not the primary determinant of graded category membership, and for a subgroup of those experts, it plays almost no role at all. Rather, both height and weediness are dimensions that function like ideals in organizing the graded structure of trees. This suggests that experts are not merely computing similarity over members of the category tree, but instead are considering specific dimensions that are important for that particular category--some of which may be goal-derived, some not--and choosing instances that maximize these ideals as good instances of tree. It is important not to overstate our case; central tendency was not irrelevant to graded category membership. Still, models which equate typicality with central tendency must take into account that extreme, rather than average, values on salient dimensions may better predict goodness of example.

The importance of ideals in determining graded category structure also has implications for category acquisition. One question raised is at what point in the learning process do ideal dimensions play a role? The answer may well vary with the nature of the ideal dimension. A goal-derived (negative) ideal dimension such as weediness may depend on prior knowledge of category instances in order to be activated as an organizing principle. One must learn a certain amount about what kinds of dimensions tree species vary on, and to what ends people plant trees, to appreciate what makes a tree a weed. Indeed, coming to consider a dimension such as weediness as relevant to a category might involve a certain amount of reorganization of existing knowledge about the category. Solomon (1997) presents similar evidence for reorganization of knowledge among wine experts. In contrast, as we argue above, height is a perceptually available ideal that may help distinguish trees from other organisms, and so may be useful as a organizing principle early in the learning process. Height was not correlated with undergraduate tree GOE ratings in the current study. However, this may be because the undergraduates were not familiar enough with the trees to know their height. One clue that height may play a role for undergraduates is the fact that the Sweet Crabapple was highly familiar, yet received a low GOE ranking. We suspect that this might be due to its height. In sum, ideal dimensions may play a role throughout the learning process, both by guiding initial category learning and by reorganizing expert knowledge.

Finally, we have been referring to the category tree as taxonomic because it is a natural category with a coherent attributional structure. Average similarity among members of the tree category could have served to distinguish trees from related categories, which is not the case for goal-derived categories. In what have commonly been called goal-derived categories (e.g. traits, things to remove from your house in case of a fire), the attributional structure of the members of the category could not serve to distinguish that category from others. Goal-related dimensions provide the necessary basis of similarity for those highly attributionally dissimilar category members. All of our expert groups have demonstrated that goal-related dimensions structure the tree category at least on some tasks. Importantly, this study provides important evidence that goals do not serve as the basis for category organization only in the absence of attributional similarity.

Conclusions

We have presented evidence that the ideal dimensions of height and weediness play a stronger role in predicting graded category structure among tree experts than central tendency. We have also presented evidence for systematic differences regarding which dimensions predict goodness-of-example for tree. These results suggest that ideal dimensions are important in determining category structure not only for goal-derived categories lacking correlated attributes, but also for taxonomic categories with strong attribute structure. Given these results, current models of categorization and conceptual acquisition that equate goodness-of-example with central tendency may well misrepresent a basic determinant of human category structure.

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Tree Species	Expert GOE[1]	Novice GOE	Novice ID Fam	Expert ID Fam	Expert Work Fam	Expert Folk CT[2]	Height	Weed	Freq[3]
American Beech	13	25	0.26	-0.32	-0.96	-0.07	60	0	1.68
American Elder	47	33	-0.47	-1.62	-1.41	0.1	9	3	0
American Elm	5	3	0.82	0.26	0.90	-0.02	70	1	3.77
American Hornbeam	40	39	-0.97	-0.74	-0.52	-0.05	25	0	1.72
Amer. Mt. Ash	38	31	-0.46	-0.21	-0.65	0.01	20	1	0.7
Amer. Sycamore	12	10	0.66	0.28	0.29	-0.1	63	2	2.38
Amur Maple	46	1	0.41	0.08	0.05	-0.08	17	0	1.46
Austrian Pine	26	8	0.45	0.04	0.23	0.24	55	0	1.6
Black Cherry	35	26	0.47	-0.57	-0.45	0.06	55	3	0.78
Black Walnut	7	17	0.55	-0.06	-0.49	-0.05	63	0	1.08
Boxelder	45	35	-0.13	0.67	0.75	-0.02	40	13	2.07
Bur Oak	3	6	0.65	0.11	0.28	-0.17	75	0	2.04
Catalpa	31	41	-0.92	0.53	-0.34	-0.07	50	6	1.91
Colorado Spruce	19	16	0.32	0.19	0.33	0.3	45	0	0
E. Cottonwood	29	32	-0.20	0.53	0.83	-0.02	88	11	1.82
E. Redcedar	42	18	0.06	-0.45	-0.24	0.31	45	1	1.57
E. WhitePine	17	12	0.53	-0.12	-0.02	0.29	65	0	1.93
Eur. Black Alder	44	42	-0.84	-0.39	-0.57	0.02	30	0	1.72
Ginkgo	21	45	-0.52	0.75	0.20	0.15	65	0	2.33
Green Ash	10	36	-0.64	-0.17	0.57	-0.09	55	0	3.28
Grey Dogwood	48	34	-0.41	-0.97	-0.92	0.11	13	0	0
Hackberry	23	40	-0.95	0.41	0.42	-0.05	50	0	3.03
Honeylocust	14	37	-0.82	0.67	1.13	-0.03	50	0	3.34
Horsechestnut	11	28	-0.58	0.37	-0.14	-0.04	63	0	1.96
Kentucky Coffee	28	47	-0.73	0.54	-0.08	-0.03	68	0	2.59
Little-leaf Linden	22	46	-0.79	0.50	0.59	0.04	85	0	2.05
London Planetree	20	44	-0.97	-0.49	-0.15	-0.07	65	0	1.2
N. Red Oak	4	2	0.72	-0.46	0.23	-0.18	45	0	3.4
Norway Maple	6	11	0.35	0.36	0.97	-0.14	68	0	2.62
Ohio Buckeye	8	27	0.45	0.27	-0.29	-0.05	30	0	1.99
Paper Birch	32	24	0.36	0.09	-0.51	0.06	60	2	0.48
Pin Oak	15	4	0.83	-0.05	0.12	-0.17	65	2	2.2
Scotch Pine	30	9	0.93	-0.48	-0.08	0.26	45	0	1.69
River Birch	25	22	0.09	0.47	0.05	0.03	55	0	0.48
Shagbark Hickory	16	20	-0.16	0.34	-0.53	-0.05	70	0	1.08
Siberian Elm	33	15	-0.08	0.35	0.57	0.01	60	11	2.34
Silver Maple	27	14	0.63	0.63	0.95	-0.14	60	3	2.89
Star Magnolia	39	30	-0.51	-0.41	-0.71	0.08	18	0	1
Sugar Maple	2	7	0.78	0.18	0.54	-0.16	68	0	3.07
Sweet Crabapple	34	19	0.71	-1.34	-0.46	0.02	20	0	2.53
Tree of Heaven	41	43	-0.79	0.54	-0.17	0.06	50	14	1.49
Tuliptree	18	48	-0.68	0.35	-0.53	0.04	43	1	2.07
Wash. Hawthorne	36	38	-0.74	-0.59	-0.16	0.06	28	0	2.61
Weeping Willow	24	13	1.68	0.51	0.14	0.06	35	10	2.49
White Ash	9	23	-0.05	-0.19	0.43	-0.09	65	0	0.7
White Mulberry	43	29	-0.24	-0.42	-0.05	0.09	40	12	0
White Oak	1	5	0.93	0.04	0.35	-0.16	65	0	0
White Poplar	37	21	0.25	0.21	-0.48	0.02	55	11	2.27

Table 1. Tree Species used, with goodness-of-example rankings and predictor values.

[1]GOE ratings were standardized for each participant and averaged across all participants for each species and the mean rank GOE scores are presented here.

[2]Central Tendency scores were standardized and multiplied by -1 (high scores equal low average sorting distance to other tree species).

[3]Raw frequencies (number of individual trees) are reported. In analyses, log frequency scores were used.

	Partial Corrs		Raw Corrs								
	Expert GOE	Novice GOE	Novice GOE	Expert CT	Science CT	Novice ID Fam	Expert ID Fam	Expert Work Fam	Height	Weed	Freq
Expert GOE			.38**	-.44**	-.06	.38**	.39**	.47**	.65***	-.40**	.37**
Novice GOE				-.11	.04	.88***	.00	.29*	.17	-.10	.08
CT folk (expert)	-.35*				.82***	-.06	-.20	-.27	-.26	.05	-.34
CT science	-0.24	-0.02				.04	-.02	-.01	.03	-.13	-.12
Nov ID Fam		.88***					.00	.19	.15	.00	.07
Exp ID Fam	0.11							.62***	.58***	.26	.36*
Exp Work Fam	0.14								.55***	.12	.54***
Height	0.54***	0.10								.02	.26
Weediness	-0.59***	-0.21									-.03
Frequency	0.09	.02									

Table 2. Raw (upper right half) and Partial (first column) Correlations Among Indices for All Participants.

Note: *p<.05, **p<.01, ***p<.001

	Maintenance GOE	Taxonomist GOE	Landscaper GOE
subgroup CT [1]	-0.31*	-0.09	-0.22
CT science [2]	-0.12	-0.09	-0.16
Exp ID Fam	0.12	0.19	0.09
Exp Work Fam	0.06	0.08	0.14
Height	0.26	0.60***	0.57***
Weediness	-0.55***	-0.50***	-0.45**
Frequency	0.04	0.18	0.14

Table 3. Partial Correlations with GOE for Subgroups, for All Trees and for Non-Weed Trees.

Note: *p<.05, **p<.01, ***p<.001

[1] This correlation does not control for subgroup CT.

[2] This correlation does not control for scientific CT.

Footnotes

[1] In general, weed trees are weak-wooded trees whose limbs tend to break in the wind, often causing them to have an asymmetric and unaesthetic overall shape. In addition they may be “dirty,” often dropping fruits (e.g. Mulberry) and large leaves (e.g. Catalpa) that clutter the sidewalks and streets and clog gutters. Weed trees may also reproduce easily and grow where they are not wanted (e.g., boxelder, tree of heaven).

[2] Boster (1988) found that similarity based upon scientific relationships predicted the graded structure of bird for a taxonomist, a South American indigenous population, and a group of North American undergraduates. Thus, there is some reason to suspect that ratings of scientific central tendency (i.e., mean similarity in a scientific taxonomy) might predict goodness-of-example ratings. We initially included such a measure, but ultimately eliminated it because (1) it was significantly correlated with “folk” central tendency (r=0.54, p<.001), and (2) it did not predict goodness-of-example on any analysis.

[3] Not every expert produced a weed tree category.

[4] All expert subgroup regressions were repeated replacing the subgroup central tendency measure from Medin, et al. (1997) with the scientific central tendency measure. This made little difference in the amount of variance explained for any group. Although the folk central tendency measure was a reliable predictor of maintenance personnel GOE ratings, scientific central tendency was not.

[5] Incidentally, ecologists, a group of tree experts not included in this study, do not agree with the experts in the current study about which trees are weeds. Rather than focus upon the relation of a tree to human goals, they focus on the role each tree plays in the ecosystem for which it evolved. For the ecologists, the weed trees are the imported trees that invade and often eventually destroy natural ecosystems. For example, the Sugar Maple, a highly typical and widely used and respected tree by the experts in the current study, is considered a destructive weed by local ecologists because it can ruin native oak woodlands by blocking oak seedlings from the sun (because it can grow in the shade and oaks cannot). Thus, weediness is in the eye of the beholder.