Journal of Experimental Psychology: General

VOL. 113, NO. 2 JUNE 1984

Objects, Parts, and Categories

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SUMMARY

Concepts may be organized into taxonomies varying in inclusiveness or abstraction, such as *furniture, table, card table* or *animal, bird, robin.* For taxonomies of common objects and organisms, the basic level, the level of *table* and *bird,* has been determined to be most informative (Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976). Psychology, linguistics, and anthropology have produced a variety of measures of perception, behavior, and communication that converge on the basic level. Here, we present data showing that the basic level differs qualitatively from other levels in taxonomies of objects and of living things and present an explanation for why so many measures converge at that level.

We have found that part terms proliferate in subjects' listings of attributes characterizing category members at the basic level, but are rarely listed at a general level. At a more specific level, fewer parts are listed, though more are judged to be true. Basic level objects are distinguished from one another by parts, but members of subordinate categories share parts and differ from one another on other attributes. Informants agree on the parts of objects, and also on relative "goodness" of the various parts. Perceptual salience and functional significance both appear to contribute to perceived part goodness. Names of parts frequently enjoy a duality not evident in names of other attributes; they refer at once to a particular appearance and to a particular function.

We propose that part configuration underlies the various empirical operations of perception, behavior, and communication that converge at the basic level. Part configuration underlies the perceptual measures because it determines the shapes of objects to a large degree. Parts underlie the behavioral tasks because most of our behavior is directed toward parts of objects. Labeling appears to follow the natural breaks of perception and behavior; consequently, part configuration also underlies communication measures. Because elements of more abstract taxonomies, such as scenes and events, can also be decomposed into parts, this analysis provides a bridge to organization in other domains of knowledge.

Knowledge organization by parts (partonomy) is contrasted to organization by kinds (taxonomy). Taxonomies serve to organize numerous classes of entities and to allow inference from larger sets to sets included in them. Partonomies serve to separate entities into their structural components and to organize knowledge of function by components of structure. The informativeness of the basic level may originate from the availability of inference from structure to function at that level.

Gallia est omnis divisa in partes tres. Gaul as a whole is divided into three parts. How many essays, since Caesar's account of his European campaign, have begun by decomposing the subject matter into parts? Knowing the parts of a topic and their interrelationship seems to be fundamental to comprehending the topic, whether the topic is a country under siege, a scientific discipline, or an automobile in need of repair. In this article, we examine the special role of parts in determining the *basic* or preferred level of abstraction in a taxonomy.

The world is filled with an overwhelming variety of objects and living things. One of the most fundamental aspects of human thought is the ability to perceive similarities and differences in objects and organisms, and to thereby group or classify them. Grouping individuals into categories gives us a basis for treating different objects and organisms as equivalent and enables us to reduce the numbers of entities in the world to manageable proportions. Classification also allows us to infer properties of individuals from knowledge of the category and to communicate information economically by category labels. The utility of categories can be further increased by organizing them into taxonomies of inclusiveness or abstraction. The animal taxonomy is a classic example. Robins, for example, are included in the class of birds, and birds are included in the class of vertebrates. The more inclusive classes are more abstract in that the features characterizing the class are more general and less concrete. Such structures allow succinct representation of knowledge and provide powerful potential for inference.

This research was supported by National Science Foundation Grant BNS 8002012 and National Institute of Mental Health Grant MH 34248 to Stanford University. Kathleen Hemenway was supported by a National Science Foundation Fellowship. Portions of this research were reported in a dissertation by Hemenway in partial fulfillment of the doctorate degree. Kathleen Hemenway is now at Bell Laboratories, Murray Hill, New Jersey.

We would like to express our gratitude to Barbara Malt, Edward Smith, Carolyn Mervis, and Eleanor Rosch for generously providing us with data to analyze, and to Allan Collins, Herbert Clark, Joachim Hoffman, Ellen Markman, Edward Smith, and Ewart Thomas for helpful discussion.

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What determines how different entities are grouped into categories, or how a general category is divided into subcategories? At one time, it was thought that category groupings were arbitrary, a matter of convention, different from culture to culture. Recent research in anthropology, linguistics, philosophy, and psychology has uncovered regularities in classification across languages and has linked characteristics of natural categories to structure in the perceived world (e.g., Berlin, 1972; Berlin, Breedlove, & Raven, 1966, 1973; Berlin & Kay, 1969; C. H. Brown, 1977, 1979; Hampton, 1979, 1981; Rosch & Mervis, 1975; Rosch, Mervis, Gray, Johnson, & Boyes–Braem, 1976). In their investigation of the internal structure of natural categories, Rosch and Mervis (1975) observed that attributes aren't evenly distributed over objects in the world; some attributes tend to co-occur with certain other attributes. For example, the attribute *has a beak* tends to co-occur with the attributes *flies, has wings, eats worms* and *builds nests.* Consequently, there are groups of entities, like birds, sharing many attributes with one another, and sharing few attributes with other entities. Rosch and Mervis showed that natural categories reflect this structure in the world: Categories group things that share attributes.

A preferred level of reference, or basic level of categorization, is a second characteristic of natural categories that has been linked to structure in the perceived world (Berlin, 1972; Berlin et al., 1973; Rosch et al., 1976). In essence, the basic level phenomenon is that categories at one level of specificity in a taxonomy are psychologically and linguistically more primary than more general and more specific categories. Relative informativeness has been used by Rosch et al. (1976) to identify the basic level. This has been operationalized as a relatively steep rise in the number of attributes listed by subjects for objects described at several levels of abstraction. For instance, subjects list very few attributes for *vehicles, furniture,* and *tools,* but list a far greater number of attributes for *car, table,* and *hammer.* Only a few additional attributes are listed for *two-door car, card table,* and *ball-peen hammer.* It has been suggested (Rosch, 1978) that basic level categories are most informative because, given our perceptual apparatus and the structure in the world, this is the level at which the natural correlations and discontinuities among features are most salient. Presumably, where informativeness is greatest, so is the inferential power of categorization.

Many empirical operations converge at the basic level in common taxonomies of objects and organisms. Basic level categories are the most general categories having members with similar and recognizable shapes; they are also the most abstract categories for which a single image can be formed for the category (Rosch et al., 1976). Basic level categories are the most general categories having members that are interacted with in the same ways (Rosch et al., 1976). In labeling an object, basic level terms are preferred (R. Brown, 1958; Cruse, 1977; Rosch et al., 1976), and in verification, basic level labels are verified most rapidly (Murphy & Smith, 1982; Rosch et al., 1976). Basic level terms tend to be the first categories named and understood by children (Mervis & Rosch, 1981), the first terms to enter a lexicon, shorter and less derived terms (Berlin, 1972; Rosch et al., 1976), and contextually neutral (Cruse, 1977). The first two measures reflect our perception of objects, the next measure reflects our behavior toward objects, and the final measures reflect our communication about them. It remains to be explained why so many different and significant operations converge at the same level.

Although the basic level of reference has been defined quantitatively, there seem to be qualitative differences among the levels of abstraction in common taxonomies (Rosch et al., 1976; Smith, Balzano, & Walker, 1978). Specifically, superordinate categories seem to primarily share functional features—vehicles are for transporting, and tools are for fixing. They do not seem to share perceptual features, in sharp contrast to objects belonging to the same basic level category, which appear to share both perceptual and functional features. On closer examination of the attributes listed by subjects, it appeared to us that one kind of feature especially predominates at the basic level of reference, namely, parts. Attributes listed for *screwdriver* include *handle* and *blade,* and attributes listed for *chair* include *seat, back,* and *legs.* Although object parts are portions of wholes, and therefore perceptual features, many names of parts seem to have a special status in that they are at once perceptual and functional. They refer to both a perceptually identifiable segment of an object and to a specialized function of the object. A *handle,* for instance, is typically long, thin, and of a size compatible with the human hand; a handle is used for grasping. Likewise, a *blade* is also elongated, with one of its long edges thinner and sharper than the other; it is used for cutting. Similarly, a *seat* is a squarish, horizontal surface, of a size and height to be compatible with humans; it is used for sitting. The other sorts of attributes generated by subjects, for instance, *red, found in water, heavy, used for fixing,* do not have this dual character. Thus part names, in contrast to names of other attributes describing objects and organisms, have two faces: one toward appearance, the other toward function.

In these studies, we garner evidence supporting the proposal that it is the psychological prevalence of parts that grants special status to the basic level; that parts underlie the distinctiveness of objects from one another at the basic level, and that parts underlie each of the types of converging operations, and thereby account for their convergence. These claims entail three predictions, to be examined empirically. First, knowledge about parts is expected to underlie the superior informativeness of the basic level. Second, because part structure is expected to underlie the natural breaks or discontinuities at the basic level, different objects at the basic level should differ on parts and share other attributes. Third, different subordinate objects belonging to the same basic level category should share parts and differ on other attributes. Following Rosch (1978), we refer to issues concerning inclusion and abstraction relations between categories as the *vertical* dimension of categorization, and to issues concerning the relations among subcategories at the same level of analysis as the *horizontal* dimension of categorization. The first prediction, then, is a prediction about representation of vertical relations among categories, and the next two predictions are about representation of the horizontal relations.

These predictions were explored for categories of plants and animals as well as for categories of common objects. Although it is difficult to identify defining characteristics of members of object categories, functional characteristics are probably at least as important as form and structure in determining membership in those categories. For example, functional *sit-on-able-ness* is at least as important a determinant of membership in the chair category as is possessing a chairlike shape. In contrast, biological categories at all taxonomic levels are morphologically based: Membership in the most general categories is determined by gross morphological features, whereas membership in the most specific categories is determined by fine structural details (Dougherty, 1978; Hunn, 1976). Because biological categories at all taxonomic ranks are morphologically based, it is not likely that basic level categories are the most general categories having members with the same parts. Members of all categories, even very general ones, probably share some parts. Even so, the extent of perceived differentiation in terms of parts and other attributes may vary with taxonomic level.

The biological categories, then, are an especially important test of our predictions because they have a part structure even at all levels of description. If we can demonstrate in biological categories a level of abstraction for which few, if any, parts are listed, followed by a level for which many parts are listed, this is strong evidence for our claim that it is the psychological salience of parts that underlies the basic level of reference. Biological categories are also important because they are cultural universals and were present during the evolution of humankind, in contrast to object categories, which may differ from culture to culture.

STUDY 1: PARTS PREVAIL AT THE BASIC LEVEL

In this study, we demonstrate that the sharp increase in attributes listed from the superordinate to the basic level is accounted for by one kind of attribute listed by subjects, namely, parts. In this and subsequent studies, we follow the methods of Rosch et al. (1976) in many cases, reanalyzing their data by separating attributes into parts and nonparts. In reporting our results, we separate findings for object categories from findings for biological categories. One reason for this was that Rosch et al. did not find direct evidence for a basic level for biological categories. Another reason for treating objects separately from biological entities was the possibility, discussed earlier, that perceived parts would play a role in determining the basic level for objects, but not for living things.

Object Categories

Method

Collection of Attributes

Criteria of frequency and depictability of instances led Rosch et al. (1976) to select six superordinate categories (clothing, fruit, furniture, musical instruments, tools, and vehicles), three basic level categories from each superordinate, and two subordinates from each basic level category. Although *fruit* is in some sense a biological category, it can also be regarded as an object category, since it is a human-defined part of a tree, engineered, packaged, and marketed much like a manufactured object. Rosch and her colleagues collected attribute norms according to a three-phase procedure described briefly here. In Phase 1, a large number of subjects were given 90 s to list attributes for each category; each subject listed attributes for categories at only one level of abstraction, and for only one category from each superordinate. In Phase 2, the attributes were tallied, and every attribute listed by less than one third of the subjects was eliminated, removing idiosyncratic responses. In Phase 3, other subjects, "judges," amended the attribute lists. The judges removed attributes they felt were not true of all category members, and added attributes if they felt the attributes were true of all category members; however, they could only add an attribute if it was already included in the list. Additions and deletions made by all 7 judges were included in the final tally. These two procedures—adding and deleting attributes—made the attribute lists logically consistent, so that properties attributed to a category were also attributed to all its subcategories.

Separating Parts From Other Attributes

Both the judge-amended and the nonamended attribute norms collected by Rosch et al. (1976) were separated into "parts" and "other attributes" according to three coinciding criteria. These norms were obtained through the good graces of Mervis and Rosch, and are used with permission. One criterion was a dictionary definition criterion. Several themes were repeated in the dictionaries we consulted: A part is one of the segments or portions into which something is regarded as divided; a part is less than a whole; together, parts constitute a whole. A second criterion was derived from Miller and Johnson-Laird's (1976) lucid discussion of relations that generate hierarchies. They distinguish a *taxonomic,* or *kind of* relation, from a *partonomic,* or *part of* relation. Whereas a taxonomic relation is expressed in an *is a* sentence frame, as in, A dog is an animal, a partonomic relation is expressed in a *has a* sentence frame, as in, A dog has a leg. This is not to say that all *is a* sentences express taxonomic relations or to say that all *has a* sentences express partonomic relations. However, for the attributes actually obtained, those that fit into a *has a* sentence frame were parts. Thus, the attributes *handle, teeth, blade,* and *edge,* listed for saw fit into a *has a* sentence frame, whereas *cuts* and *sharp* do not. A third criterion was the majority judgment of naive subjects who were asked to designate which of the attributes listed for 80 objects they regarded as parts. All of the attributes judges determined to be parts fit into a *has a* sentence frame, with the addition of material composition. Judges determined that attributes having an *is made of* or *is partially made of* relation to the object were also parts. These constituted only 9% of the parts attributes. The attribute *wood* listed for guitar is an example. *Wood* seems to be in lieu of *frame* or *body* in this instance and in others like it. Note here that *wood* also fits the dictionary definition of part. Additional justification for including material composition as parts comes from a separate study in which subjects, asked to list parts of objects, frequently listed parts by the materials they are made of. For example, *wood* and *metal* were commonly listed as parts of a screwdriver, instead of *handle* and *blade*. Finally, the form class of the attribute was helpful for distinguishing parts from other attributes. All of the parts listed were nouns, and most of the nouns listed were parts; the nouns that were not parts were *driver* and *passenger* for car and bus, and *chairs* for kitchen table. The nonpart attributes were adjectives (*loud, crispy, green, comfortable*) or else verb phrases or sentence fragments (*you eat on it, gives light, requires gas, lives in water*). Attributes considered to be parts, then, refer to segments of wholes that are less than wholes; they are judged by a majority of naive informants to be parts, and they fit into a *has a* or *is made of* or *is partially made of* sentence frame.

In Table 1 the attributes from some of the categories reported in Rosch et al. (1976) are displayed, separated into parts and nonparts. The careful reader will notice that *keys, black keys,* and *white keys* are all listed for piano, and *legs* and *four legs* for chair. Since the judges passed on these attributes, we had no choice but to leave them in as well. Redundant attributes constituted a small portion of the attributes, and leaving them out does not change the pattern of findings.

Results

Judge-Amended Tallies

In order to give equal weight to each category (because some categories elicit more attributes than others), the number of part and nonpart attributes were computed for each category and averaged over categories for each level of analysis. This technique was adopted throughout the research. Overall, 58% of the attributes were parts; however, the percentage varied with taxonomic level, as predicted. Parts were infrequent at the superordinate level and frequent at the basic and subordinate levels: Only 20% of the superordinate level attributes were parts, whereas 64% of the basic level attributes were parts, and 60% of the subordinate level attributes were parts.

In Figure 1 the mean numbers of parts and other attributes in the judge-amended tally are displayed as a function of level of abstraction. For both parts and other attributes, the difference between the superordinate and basic levels is significantly larger than the difference between the basic and subordinate levels, $t(5) = 3.89$, $p < .01$; $t(5) = 3.48$, $p < .01$, and this disparity is more marked for parts than for other attributes, as predicted, $t(5) = 2.82$, $p < .01$. Also, the difference between the basic and subordinate levels is larger for other attributes than for parts, $t(5) = 2.77$, $p < .025$.

Nonamended Tallies

Numbers of parts and nonparts were averaged over categories for each level of abstraction, as before, to equalize the contribution of each category to the part partition. Overall, 57% of the attributes were parts; again, the proportion of parts to other attributes varied with level of abstraction. Thirty-eight percent of the superordinate level attributes were parts, 66% of the basic level attributes were parts, and 58% of the subordinate level attributes were parts.

In Figure 2 the mean numbers of parts and other attributes occurring at each level of abstraction are displayed. Subjects listed more parts at the basic level than at the subordinate level. The number of parts listed for each basic level category was significantly higher than the mean number listed for its subordinates (sign test $z = 2.58$, $p < .005$).

Biological Categories

Method

Selection of Categories

The superordinate categories used were plant and animal. The basic categories bird, fish, tree, and flower were chosen because attribute lists for 15 subordinates of each of those categories had been collected by Malt and Smith (1982), and they kindly allowed us to reanalyze their data. We asked 30 undergraduates at Stanford to rate the subordinates for familiarity, and selected 4 subordinates from each set of 15 on this basis.

Attribute Listing

Subjects. In this and subsequent studies, unless noted otherwise, subjects were Stanford introductory psychology students participating for course credit, or infrequently, for pay. Subjects were run in small or large groups, and sometimes participated in other, unrelated experiments in

Table 1
Judge-Amended Attributes Divided Into Parts and Other Attributes

	Musical instrument Makes sound	
Guitar Strings* Tuning keys* Neck* Hole* Wood* Makes music You strum it Used by music groups	Piano Keys* Foot pedals* Strings* Legs* Lid* Wood* Black keys* White keys* Makes music	Drum Sticks* Skins* Round Loud Used by music groups
Classical guitar (No additional)	Upright piano (No additional)	Kettle drum (No additional)
Folk guitar (No additional)	Grand piano Large Used in concert halls	Bass drum (No additional)
	Fruit Seeds* Sweet You eat it	
Apple Stem* Core* Skin* Juicy Round Grows on trees	Peach Pit* Skin* Yellow–Orange Fuzzy Soft Grows on trees	Grapes Juicy Bunches Makes wine Grows on vine
Delicious apple Red Crisp Shiny Tasty	Freestone peach (No additional)	Concord grapes Purple
Macintosh apple (No additional)	Cling peach Juicy Canned	Green seedless grapes Green Small
	Furniture (No attributes)	
Table Legs* Top* Surface* Wood* You eat on it You put things on it	Lamp Light bulb* Shade* Cord* Switches* Base* Gives light You read by it	Chair Legs* Seat* Back* Arms* Comfortable Four legs* Wood* Holds people You sit on it
Kitchen table Chairs	Floor lamp (No additional)	Kitchen chair (No additional)
Dining room table Four legs*	Desk lamp (No additional)	Living room chair Large Soft Cushion*

Note. Judge-amended attributes selected from "Basic objects in natural categories" by E. Rosch, C. B. Mervis, W. Gray, D. Johnson, and P. Boyes-Braem, 1976, *Cognitive Psychology, 8,* pp. 435–436. Copyright 1976 by Academic Press. Adapted by permission. Lower levels include all attributes listed at higher levels. Parts are indicated by *.

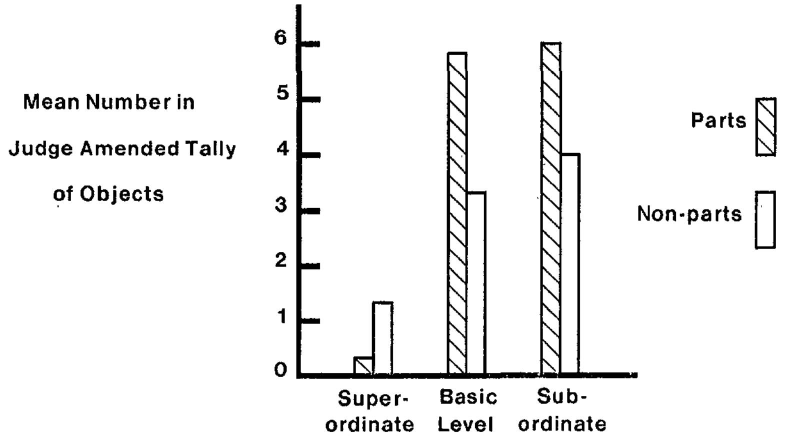

Figure 1. Mean number of parts and other attributes listed by subjects and amended by judges for object categories at three levels of abstraction.

the same session. There were 45 subjects in the present experiment; 15 subjects listed attributes for each superordinate and basic level category. In Malt and Smith's (1982) experiment there were 240 subjects, and 16 subjects listed attributes for each subordinate category. To make their data comparable to previous data, 1 of their subjects was randomly eliminated.

Materials. The booklets used in the present experiment were identical in format to those used by Rosch et al. (1976) and by Malt and Smith (1982). The booklets consisted of an instruction page, and several pages, each of which had a category label, either plant and animal or one kind of plant (tree or flower) and one kind of animal (bird or fish) at the top and was blank otherwise. Each booklet in Malt and Smith's experiment included four subordinate category labels (one kind of bird, one kind of fish, one kind of flower, and one kind of tree) as well as four unrelated basic category labels. Pages were collated in random order for each subject.

Procedure. The instructions were read aloud to subjects, and then the subjects were timed while they listed attributes for each category. The attributes were tallied and attributes listed by a third or more of the subjects were included in the final nonamended lists. These lists were used in the judge-amending phase. The instructions and procedure were similar to those used by Rosch et al. (1976). Malt and Smith (1982) also used the Rosch procedure, except that they allowed subjects only 75 s per item for listing attributes.

Judgment of Attributes

Subjects. Another group of 10 students judged the truth of the attributes.

The following methods were used in this and subsequent judge-amending phases.

Materials and procedure. Booklets consisted of an instruction page, followed by separate pages for each basic category. The attributes listed by 2 or more subjects for a basic level category, its superordinate, or its subordinates

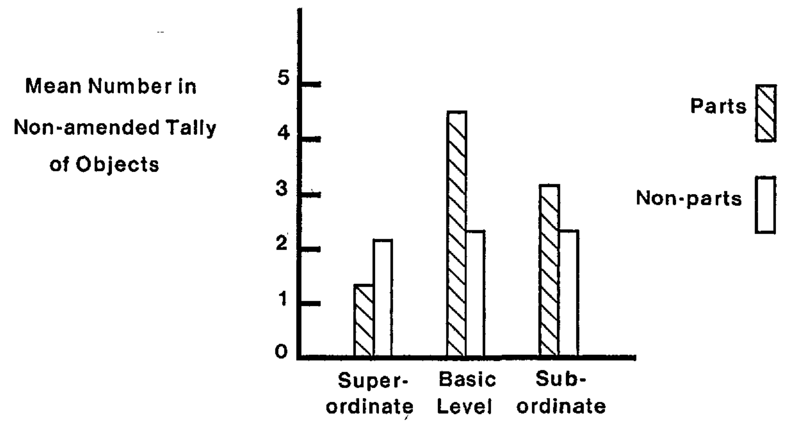

Figure 2. Mean number of parts and other attributes listed by subjects for object categories at three levels of abstraction.

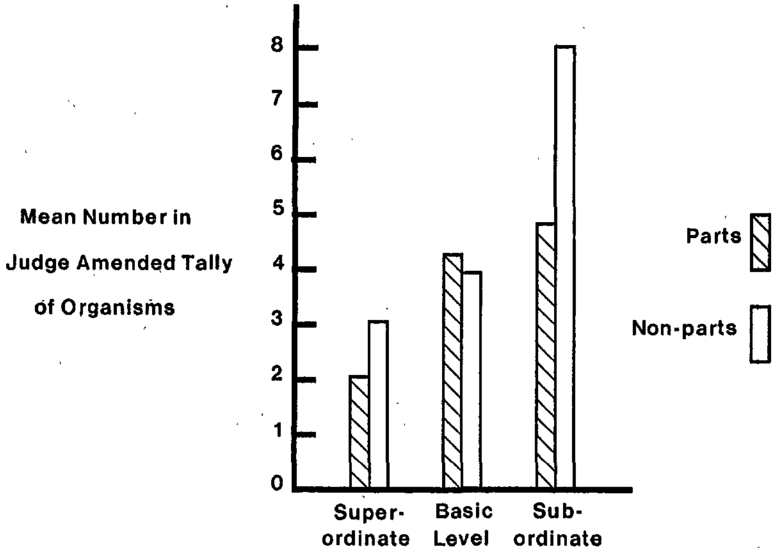

Figure 3. Mean number of parts and other attributes listed by subjects and amended by judges for biological categories at three levels of abstraction.

were typed in random order down the side of a page. The superordinate, basic, and subordinate category names were typed across the top of the page. Pages were collated randomly for each subject.

The experimenter read the instructions aloud to subjects while they read along silently. The instructions were very similar to those used by Rosch et al. (1976) and asked subjects to judge whether each attribute was true of each category listed across the top of the pages. The task was self-paced.

An attribute was included in the judge-amended norms for a category if a majority of the judges indicated possession. Logical consistency was not enforced; that is, an attribute was included for a category if a majority of the judges indicated possession, regardless of whether the attribute was included in the lists for all subcategories.

Results

Judge-Amended Attribute Tallies

As before, numbers of parts and nonparts were averaged over categories at each level of analysis. Overall, 42.7% of the attributes were parts. As before, the percentage varied with taxonomic level. Forty percent of the superordinate attributes were parts, whereas 52% of the basic level attributes were parts. The proportion of parts declined to 38% for subordinate level categories. In Figure 3 the mean numbers of parts and other attributes as a function of taxonomic level are displayed. As expected, biological categories are perceived to share parts even at the superordinate level. *Stem* and *roots* were listed for plants, whereas *tail* and *eyes* were listed for animals. Some of the judge-amended norms are reported in Appendix A.

Nonamended Attribute Tallies

Numbers of parts and nonparts were averaged over categories at each level of analysis. Overall, 49.6% of the attributes were parts. For the nonamended tallies, the variation in proportion of parts with taxonomic level is even more striking: Parts constituted only 25% of superordinates, 70% of basic level attributes, and 46% of subordinate attributes. The decrease in number of parts listed from basic level to subordinate level was significant, $t(3) = 9.52$, $p < .005$. At the superordinate level, subjects listed significantly fewer parts than other attributes, for example, plants: $t(14) = 6.44$, $p < .005$; animals: $t(14) = 2.90$, $p < .01$. The mean numbers of part and nonpart attributes listed at each taxonomic level are displayed in Figure 4.

Raw Attribute Lists

Two analyses of the attribute lists obtained from Phase 1 shed light on the role of knowledge of parts in taxonomically organized categories. Parts were separated into modified

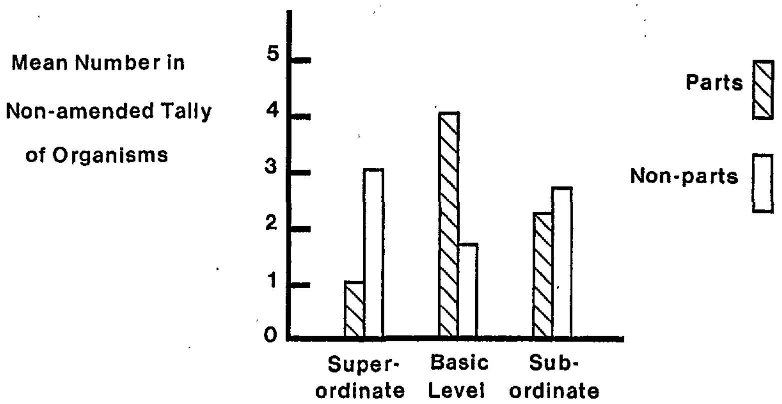

Figure 4. Mean number of parts and other attributes listed by subjects for biological categories at three levels of abstraction.

(e. g., *red petals*) or unmodified (e. g., *petals*). Quantified parts (e. g., *two eyes*) were infrequent and were excluded from the analysis. At the superordinate and basic levels, 12% and 10% of the parts were modified, respectively, whereas at the subordinate level, 34% were modified. Although, overall, fewer parts were listed at the subordinate level than at the basic level, more than twice as many modified parts were listed at the subordinate level. This result is consistent with the hypothesis that characteristics of parts are distinctive of contrasting subordinates.

The order in which subjects list attributes should be indicative of the relative importance of the attributes for the categories. If parts are particularly salient at the basic level, they should be listed earlier than other attributes. Attribute lists for each subject were split in half by order of output, and the percentage of parts listed in each half were computed. At the superordinate level, 48.5% of the parts were listed in the first half of the output, and at the subordinate level, 53% of the parts were listed in the first half of the output. In contrast, 71% of the parts in the basic level occurred in the first half of the output. Matched pairs t tests revealed a significant bias to name parts earlier for each basic level category; flower: $t(14) = 5.68$, tree: $t(14) = 3.59$, fish: $t(14) = 2.83$, and bird: $t(14) = 3.31$, all ps $< .005$; no bias for either of the superordinate categories ($t < .2$); and no bias for 14 out of 16 of the subordinate categories (for 13 categories, $t < 1$; for sparrow, $t = 2.20$, $p < .05$; for chicken, $t = 2.70$, $p < .02$).

Discussion

Parts dominate attribute lists at the basic level for amended and nonamended norms, for object and biological categories. Although parts are a minority of superordinate attributes, the majority of attributes listed at the basic level are parts. The proportion of parts listed decreases from the basic to the subordinate levels, becoming a minority of the attributes for biological categories. Only the parts attributes show the sharp rise in numbers from the superordinate to the basic level, taken as the definition of the basic level. Inclusion of other attributes attenuates this effect, especially in the biological categories. The comparison between the amended and nonamended norms is instructive. The amended norms force or encourage consistency on the tallies; attributes included in categories were also usually included for subcategories, because they were usually true of subcategories. This is consistent with the notion that more specific categories carry more information. However, the nonamended tallies tell a different story. More attributes are listed at the basic level than at the superordinate level, but fewer attributes are listed at the subordinate level than at the basic level. This drop in accessed knowledge with increasing specificity of category is completely attributable to the drop in numbers of parts listed. A desk lamp contains the same parts as a lamp, and double-knit pants contain the same parts as pants; however, subjects list fewer parts for desk lamp than lamp and fewer for double-knit pants than for pants. Moreover, a larger share of the parts listed at the subordinate level are modified parts, such as *white petals*. Because when judges amend the tallies, they add attributes (particularly parts) to the subordinate categories, we can infer that subjects know that sedans have carburetors and pine trees have trunks, even if the subordinate label fails to elicit them. Thus, the amended norms reflect the knowledge subjects have, whereas the nonamended norms reflect subjects' performance in this sort of task.

What determines the sorts of attributes subjects list for objects and entities? Despite the popularity of category and attribute norms (e.g., Ashcraft, 1978; Hampton, 1979, 1981; Malt & Smith, 1982; Rosch et al., 1976), their status has not received much discussion. How can we account for the failure to list parts and other attributes for objects, especially at the subordinate level of specificity, in spite of the fact that subjects judge these attributes to be true for those objects? Observation of the attribute lists suggests that in listing attributes, subjects attempt to be informative about the objects (Grice, 1975) to convey the knowledge they have about the categories. They give us good clues as to how to recognize the objects and as to what the objects are used for. Subjects also attempt to be relevant, for they do not say all they know about the objects. They tell attributes important for distinguishing the appearance or function of the object, so the smell of flowers and taste of fruit are mentioned, but not the smell or taste of clothing. They list fewer attributes at the subordinate level than at the basic level in spite of the fact that they know more attributes at the subordinate level. Subjects don't list *molecules* or *inanimate* or *cells* or *animate*, although the former two are properties of objects and the latter two are properties of living things. Subjects, then, are informative and relevant, but in the context of an implicit contrast set (see Garner, 1974; see also the discussion of contrastive field properties in Miller & Johnson–Laird, 1976). Interestingly, the implicit contrast set seems to be other objects at the same level of abstraction. More general features seem to be presupposed, and go unmentioned. So, it is more informative to mention *trunk* for tree than for pine tree, because tree contrasts with grass or bush or perhaps even more remote entities, and *trunk* is a property of trees, but not of these contrasting entities. Because the implicit contrast set for *pine tree* will include other trees, listing *trunk* is not as informative, as it is shared by all trees, but listing *needles* is informative.

The parts norms (but not the nonparts norms) for biological categories establish directly that the basic level for biological categories for American college students is the level of tree, flower, fish, and bird, with plant and animal as superordinates. Previous work had shown that the level found to be basic (generic) in folk taxonomies (Berlin, 1978), namely, pine, bass, was not basic according to the Rosch et al. (1976) criterion. In fact, the data for object and biological categories look remarkably similar, despite the fact that biological categories are defined morphologically at all levels of abstraction, whereas superordinate object categories appear to carry functional meaning as well. Superordinate biological categories are judged to share a few parts, whereas superordinate object categories are not; however, the nonamended norms do not show this difference. For the biological categories, the basic level is less sharply defined. Inclusion of other attributes in addition to the parts attributes so attenuates the relationship of attributes to taxonomic level as to preclude establishment of a basic level for biological categories.

Although these studies have been directed at a vertical analysis of categories related by inclusiveness in a taxonomy, the results are suggestive of phenomena occurring horizontally, or between categories at the same level of analysis. We have seen that the attributes subjects list for categories are informative and relevant within an implicit contrast set, that is, characteristic and distinctive of the object in comparison to objects it is not. The prevalence of parts at the basic level suggests that, especially at that level, objects should differ from one another on the basis of parts and share other attributes. This is tested directly in the next set of studies.

STUDY 2: BASIC LEVEL CATEGORIES DIFFER BY PARTS

To test that basic objects differ from one another by parts and share other features, we examined attribute lists for a large number of basic level entities for each of four object and two biological categories. Finding that categories at the basic level differ from one another on the basis of parts but share other attributes would indicate that the perceived natural breaks among categories at that level are between clusters of shared parts.

Because a large number of basic and subordinate categories are needed for this analysis, it could not be performed on the data from Study 1. The attributes for 20 kinds of clothing, furniture, vehicles, and weapons were generously contributed by Rosch and Mervis (1975). Their data were collected using the three-phase procedure described earlier. These instances varied considerably in absolute frequency, production frequency (to superordinate name), and typicality vis-à-vis the superordinate category. No such lists of instances or of attributes existed for animals and plants, so we collected them. Interestingly, the six plant categories produced by our subjects (flower, tree, fern, grass, bush, vine) correspond closely to the life-form categories found in a large number of folk botanical taxonomies by Witkowski and C. H. Brown (reported in C. H. Brown, 1977). The animal categories selected were also at the life-form level as determined by cross-cultural ethnological studies (Berlin, 1978).

Object Categories

Method

Subjects

The subjects were 10 naive staff persons in the Department of Psychology at Stanford who completed the booklets at their leisure.

Materials and Procedure

Booklets were compiled according to the following procedure. Separate forms were used for each superordinate category. The 20 basic categories from a superordinate were listed at the top of each page, and the attributes from the corresponding composite attribute list were typed, in a random order, below the list of categories. The pages were collated in a different random order for each subject (with the constraint that all the pages for one superordinate always occurred together). The subjects were instructed to circle all the attributes they considered to be parts on each of the pages. They were not told what a part is: However, they were told that *ears* and *trunk* are parts of an elephant, whereas *large, gray,* and *eats peanuts* are not.

Results and Discussion

Every attribute circled by a majority of the subjects was considered to be a part. Then, each attribute was assigned a weight equal to the number of basic level categories from the same superordinate possessing the attribute. Because of the high variability of these weights, the median (rather than the mean) weights for parts and nonparts were computed. Displayed in the top section of Table 2 are the median weights for parts and nonparts. For each category, the parts median is smaller than the nonparts median, $t(3) = 5.14$, $p < .01$. This result indicates that parts are more distinctive of contrasting basic categories than are nonparts, confirming our hypothesis that subjects list more parts at the basic level because parts are the distinctive features of objects at that level. Thus, parts contribute more than nonparts to the naturalness of basic level category cuts.

Table 2
Median Number of Basic Level Categories Sharing Parts and Other Attributes

	Median weight	
Type of category	Parts	Other attributes
Object		
Clothing	3	5
Furniture	1	2
Vehicles	3	6
Weapons	1	2.5
Biological		
Animals	2.5	4
Plants	2.5	3

This result may also seem to imply that parts are working against the integrity of superordinate categories. After all, shared features are what "glue" a category together, and shared features are associated with the prototypicality of a category member (Rosch & Mervis, 1975). Because nonparts are more likely to be shared than parts, one may infer that sharing nonparts would be more predictive of prototypicality than sharing parts. To answer this question, separate family resemblance scores were computed on parts and nonparts, and each family resemblance score was correlated with typicality. The parts and the nonparts family resemblance scores correlated equally and highly with typicality, and with each other. So, although for these natural categories, parts and other attributes are equally associated with the typicality of instances of the same superordinate, only parts distinguish instances from one another.

Biological Categories: Elicitation of Instances

Method

Forty-one subjects were given small booklets with a cover page that the experimenter read aloud. The rest of the booklet consisted of a page titled "Plants" and another page titled "Animals," collated in random order. The instructions informed the subjects that each page of their booklets named a kind of thing, and that they would have 60 s to write down "items people commonly give as belonging to various categories or classes." The instructions also included an example.

Results

From the animals listed by 2 or more subjects, 20 animal categories were selected so that no category included another and so that the entire range of production frequency and produced genera were sampled. Thus, the list contained bee, ant, fish, snake, frog, bird, turtle, and alligator, as well as 12 mammals varying in familiarity. From the plants listed by 2 or more subjects, only six plant categories (flower, tree, fern, grass, bush, and vine) met the criteria.

Biological Categories: Attribute Listing

Method

Ten subjects listed attributes for the six plant categories and 10 other subjects listed attributes for the 20 animal categories. They were directed to list "characteristics and attributes that people feel are common to and characteristic of different kinds of ordinary everyday animals (plants)." The instructions also included a number of examples. To expedite collection of attribute norms, these subjects both generated and judged the truth of attributes. Malt & Smith (1982) compared attributes listed for common categories (e.g., lemon) when they were in the context of other categories from the same superordinate and when they were in the context of other categories from different superordinates. There were essentially no differences in the attributes produced in the two contexts, broad and narrow.

Results and Discussion

Those attributes listed by more than three judges were divided into parts and nonparts by the usual criteria. The median weights for parts and other attributes were computed, and are displayed in Table 2. Just as in the object categories, the median weights for nonparts are higher than the median weights for parts for biological categories, indicating that basic level plants and animals are perceived to share nonparts and to differ from one another on the basis of parts.

STUDY 3: SUBORDINATE LEVEL CATEGORIES SHARE PARTS

Parts, more than other attributes, distinguish one basic level entity from another. Reflection on the nature of subordinate categories as well as the decrease in parts listed at the subordinate level suggest that subordinate level categories may share the same parts and differ from one another on other attributes. We next examine that conjecture, first for object categories, and then for biological categories.

Object Categories

Attribute norms for 10 subordinates from each of four basic categories, chair, table, shirt, and pants, were compiled and analyzed. These categories were used because they were the only ones for which a substantial number of familiar subordinate category labels could be found.

Method

Subjects

There were 40 subjects in all; 10 subjects listed attributes for each set of subordinate categories.

Materials

In order to select subordinate categories, two judges (the authors) listed all the subordinate labels they could think of or find in catalogs. Brand names and unfamiliar labels were excluded from the lists. When near synonyms occurred in a list, only the more specific synonym was included. Where two labels applied to a single exemplar, one of the labels was excluded from the list whenever possible. Because many object subordinates don't form contrast sets, it was not possible to exclude all noncontrasting labels. The subordinate categories are displayed in Table 3.

Four different kinds of booklets were compiled, one for each set of subordinates. The booklets consisted of an instruction page followed by four identical forms. The 10 subordinates were listed across the top right-hand side of the forms, and blank space was left on the left-hand side for subjects to list attributes. For each attribute subjects listed, they put *x*s below the subordinates possessing the attribute.

Procedure

The written instructions were read aloud to subjects. They were asked to list "attributes, properties, and characteristics true of all the things listed across the top of the page, as well as attributes, properties, and characteristics true of only one or a few of them." Subjects worked at their own pace, listing all the attributes they could think of in 15 min.

Table 3
Nonbiological Subordinate Categories

Pants	Shirts
Corduroy pants	Dress shirt
Double-knit pants	Flannel shirt
Flared pants	Knit shirt
Levi pants	Long-sleeved shirt
Overalls	Sweat shirt
Pleated pants	T-shirt
Riding pants	Turtleneck shirt
Ski pants	V-neck shirt
Straight-leg pants	Western shirt
Sweat pants	Work shirt
Chairs	**Tables**
Beanbag chair	Card table
Dining room chair	Coffee table
Director's chair	Conference table
Easy chair	Dining room table
Folding chair	Drafting table
High chair	End table
Kitchen chair	Kitchen table
Reclining chair	Picnic table
Rocking chair	Ping pong table
Swivel chair	Typewriter table

Scoring

A subordinate category was considered to possess an attribute if at least 3 subjects indicated that the subordinate possessed it. The attributes were classified as parts and nonparts in the usual way. The parts were further classified as unmodified parts (called *parts*) and modified parts (e.g., *long sleeves, flat top*). Two of the parts in the lists occurred with quantifiers (i.e., *two legs, four legs*) and these parts were excluded from the tallies. Finally, a weight equal to the number of subordinates possessing an attribute was calculated for each attribute.

Results and Discussion

The median weights for parts and nonparts are given in Table 4. For each category the median parts weight is larger than the median nonparts weight. This result is significant, $t(3) = 3.70$, $p < .025$, and it is consistent with the other results indicating that the distinctive features of subordinate categories are nonparts. The modified parts medians were not included because so few modified parts occurred.

Biological Categories

Subordinate object categories share parts and differ from one another on other attributes. To examine the hypothesis that the distinctive features associated with biological subordinates are mostly nonparts and, to a lesser extent, modifications on parts, attribute lists for many contrasting subordinate categories were analyzed.

Method

Attribute Listing

Based on the study of familiarity of subordinates described earlier, attribute lists of Malt and Smith (1982) for the 10 most familiar subordinates from each basic category were used. The resulting set of subordinate categories is displayed in Table 5.

To match the sample size in this experiment to the sample size in the corresponding study of object subordinates, 6 of Malt and Smith's (1982) 16 subjects were randomly selected and their data were eliminated. Every attribute listed for a category by 2 or more of the remaining 10 subjects was included in the next phase of the experiment.

Judgment of Attributes

Nine subjects judged the truth of the attributes according to the usual procedure. A subordinate was considered to possess an attribute if a majority of the 9 subjects indicated possession. A weight equal to the total number of subordinates possessing an attribute was computed for each attribute. The attributes were separated into parts and nonparts according to the usual criteria, and the parts were further separated into three classes: modified, unmodified, and quantified parts. As before, the number of quantified parts was too small to be analyzed.

Results and Discussion

The median weights for parts, nonparts, and modified parts are displayed in the bottom

Table 4
Median Number of Subordinate Categories Sharing Parts, Modified Parts, and Other Attributes

	Median weight		
Type of category	Parts	Other attributes	Modified*
Object			
Pants	6	3	
Shirts	6	3	
Chairs	5.5	3	
Tables	9	2	
Biological			
Flowers	10	2	4
Trees	3	3	3
Birds	10	2	2
Fish	10	2	1

Note. * These numbers were inconsequential for object categories.

Table 5
Biological Subordinate Categories

Flowers	Trees
African violet	Bamboo
Azalea	Elm
Cherry blossom	Maple
Daisy	Oak
Iris	Palm tree
Lilac	Peach tree
Lily	Pear tree
Marigold	Pine
Poppy	Redwood
Rose	Sequoia
Birds	**Fish**
Blue jay	Carp
Chicken	Eel
Crow	Goldfish
Duck	Minnow
Hawk	Salmon
Mockingbird	Sardine
Owl	Shark
Pelican	Sunfish
Robin	Trout
Sparrow	Tuna

section of Table 4. The parts median is larger than both the nonparts median, $t(3) = 3.27$, $p < .025$, and the modified parts median, $t(3) = 2.85$, $p < .05$. The latter two medians don't differ from one another, $t(3) = .397$, *ns.* Seventy-five percent of the attributes in the norms are nonparts, 15% are parts, 9% are modified parts, and 1% are quantified parts.

On the whole, biological subordinate categories, like object subordinate categories, share parts and differ from one another on other attributes. To a certain extent, they also differ from one another in variations on parts.

DISCUSSION OF STUDIES 1-3

Taken together, these three studies indicate that parts are significantly linked to basic level category cuts: Subjects associate few, if any, part attributes with superordinate level categories, but associate a large number of part attributes with basic level concepts. Few, if any, additional parts are associated with subordinate level categories. Most of the features shared by (subordinate) members of a basic category are parts, and most of the features distinguishing one basic category from another are parts. In contrast, the features that differentiate subordinates of a basic category are mostly nonparts. Unlike at other levels of abstraction, at the basic level parts are both (a) the features common to members of a category and (b) the features distinctive of contrasting categories. Thus, the perceived natural breaks among basic level categories occur between clusters of parts, whereas the perceived natural breaks among subordinate level categories occur between other attributes. These results extend and clarify Rosch et al.'s (1976) assertion that basic level categories are more effective than categories at other levels in grouping entities that share many features and separating entities that are distinguished by many features. Parts are a better index of "basicness" than are other, purely functional or perceptual attributes; in fact, these only attenuate the diagnosis of the basic level.

The predominance of parts listed at the basic level suggests, in addition to a quantitative diagnosis, a qualitative explanation of why members of basic level categories have very similar shapes, and why they are interacted with in the same ways (Rosch et al., 1976). Because that is what the task demands, subjects give lists of parts, but in actuality, parts are organized in specific configurations. The configuration of parts, or structural description, determines the shape of objects to a large degree. Moreover, because they have virtually no distinctive parts, members of different subordinate categories don't have distinctive shapes. Similarly because we typically interact with the parts of an object (we grasp *handles,* sit on *seats,* push *buttons,* etc.), objects that have the same parts are interacted with in the same ways. We return to this analysis in the final discussion. But first, let us have a closer look at parts themselves.

STUDY 4: GOODNESS OF PARTS

We have examined the role of parts in the vertical organization of categories, in distinguishing the basic or preferred level of reference. We have also examined the role of parts in the horizontal organization of categories, in distinguishing one basic level category from another. Another way of examining the horizontal role of parts is to investigate the different parts of a particular object. Until now, we have treated all parts associated with an object as equal. However, even casual perusal of the lists of parts suggests that there is variability in the "goodness" of the parts associated with an object or organism. The *trunk* of an elephant, for instance, seems to be a very good part of an elephant. It is a perceptually salient extension of the body and has functional significance for the elephant as well as for its human caretakers and perceivers. Furthermore, the trunk is a distinctive feature of an elephant, serving to distinguish elephants from other members of the animal kingdom. Similarly, the *screen* of a television is both a perceptually salient and functionally significant part of a television, as well as a part that distinguishes it from other furniture or appliances. Other parts, including many not even mentioned by our informants, seem to be less good, because they lack functional significance or perceptual salience, or object distinctiveness, or some combination of the above. For instance, optional parts, like the *cuffs* of pants or the *buttons* of a shirt lack functional significance or perceptual salience.

Goodness of parts of an object can be viewed as analogous to typicality of members of a category, in that both are ratings reflecting the perceived internal structure of elements related to a higher-level structure. In the case of goodness of parts, the relation is a partonomic, or part–whole relation, where the elements are the parts and the higher level structure is the whole object. In the case of typicality of members, the relation is a taxonomic, or class-inclusion relation, where the elements are categories at one level of abstraction and the higher order structure is a category at a higher level of abstraction. Some category members are perceived as better exemplars of the category than others (Rosch & Mervis, 1975; Mervis & Rosch, 1981); *car* is a better vehicle than *boat,* and *couch* is a better piece of furniture than *lamp.* Subjects' ratings of typicality of member have been used to describe the internal structure of categories, to reflect the fact that some members of a category are regarded as "better" than others. If the analogy holds, subjects' ratings of goodness of part should describe the internal structure of parts and reflect the fact that some parts of an object are seen as better than others.

The study reported here is an attempt to verify the intuition that parts vary in perceived goodness, that people agree on which parts are better, and that good parts are more frequently mentioned. At the moment, the notion of good part is kept vague; this is an exploratory study, and part goodness is evaluated, not manipulated. The actual ratings prompt further discussion.

Parts Listing

Method

Subjects

The subjects were 30 students in introductory psychology at Stanford who participated for course credit.

Materials and Procedure

The booklets were identical to those used in the attribute listing study of biological categories except that the categories differed. The categories were: apple, car, chair, drum, grape, lamp, lettuce, onion, pants, piano, saw, screwdriver, shirt, and truck. Each booklet included only 7 of the 14 categories, one from each of the 7 superordinates. Each subject completed one booklet, so that 15 subjects listed parts for each category. The procedure was also identical to the procedure used in the attribute listing study of biological categories, except that subjects were asked to list parts only.

Results

The parts were tallied, and each part listed by 2 or more subjects was included in the rating experiment, described next. The low criterion of mention by 2 or more subjects was adopted to increase the range of goodness of parts. This resulted in the inclusion of parts that had been excluded from previous studies. So the list of parts (with goodness ratings) included in Appendix B is not the same list as the list used in Study 1, where parts were shown to be diagnostic of the basic level.

Goodness of Parts Ratings

Method

Materials

A separate form was made for each basic category. The category label was typed at the top of the page, and the parts were listed, in random order, down the left side. Next to each part was a 7-point scale ranging from *very good part* (1) to *not a good part* (7). The pages were collated randomly for each subject. The first page had the instructions on it.

Procedure

The instructions were read aloud to subjects while they read along silently. They were asked to judge the goodness of each part listed for the relevant object. Subjects weren't told what a good part meant; however, they were given several examples of good and bad parts. For example, they were told that *wings* are very good parts of an airplane, and that the *floor* of an airplane isn't a good part. They were also told that *hands* are good parts of a clock, while the *back* of a clock is not. Each of the 15 subjects judged parts for all 14 basic categories.

Results

The mean goodness rating was found for each part (see Appendix B for examples). The data for fruit are omitted from the analyses because several nonparts were inadvertently included. Intraclass correlations were computed on the ratings for each object; these reflect the degree of consensus among all 15 subjects. The correlations shown in Table 6 were good: They ranged from .21 to .66, indicating that people agree in the extent to which a given part is a good part.

The mean goodness ratings were also correlated with frequency of mention of the parts. Signs were reversed so that positive correlations indicate that part goodness and frequency of mention increase together. Only 7 of the 12 correlations were significant; however, the nonsignificant correlations occurred for the items having the fewest parts. These correlations are also displayed in Table 6. The correlations indicate that the parts people listed most frequently were perceived as good parts and provide some validation for the construct, goodness of part.

Both sets of correlations are probably attenuated by including only the parts listed by subjects when asked to list parts of objects, in other words, by including mainly good and "halfway decent" parts. The lists did not include, for instance, parts of other related objects, or technical part terms, or ubiquitous parts, such as molecules. Consistent with this interpretation, the goodness ratings were highly skewed, with more parts rated toward the good end of the scale. Forty-nine percent of the parts received ratings toward the good end (ratings less than or equal to 3), but only 5% of the parts received ratings toward the poor end (ratings greater than or equal to 5).

The reader may wonder why subjects gave such high goodness ratings to *light* for lamp and to *head* for lettuce, when neither *light* nor *head* passed the criteria for inclusion in the list of parts for Study 1. We believe the explanation lies in the demand characteristic of the rating task. When confronted with *head* in a list of parts for lettuce, the subject may think something like, "Well, *head* isn't really a *part* of *lettuce,* at least not as it appears in the supermarket. So, they must mean *lettuce* as a plant, in which case, it probably has roots and a stem of sorts, so *head* would be a very important part of *lettuce.*"

Table 6
Goodness Ratings: Agreement Among Subjects and Correlations With Frequency of Mention

Category	Number of parts	Intraclass correlation	Pearson P-M correlation
Clothing			
Pants	21	.32	.44**
Shirt	16	.24	.21
Furniture			
Chair	16	.33	.50**
Lamp	17	.38	.42*
Musical instruments			
Drum	16	.32	.38
Piano	20	.51	.50**
Tools			
Saw	10	.66	.36
Screwdriver	6	.39	.45
Vegetables			
Lettuce	11	.66	.53*
Onion	6	.35	.09
Vehicles			
Car	48	.25	.42***
Truck	33	.21	.39**

* $p < .05$. ** $p < .025$. *** $p < .01$.

Discussion

To a large degree, our subjects agreed on which parts are good parts of an object. Goodness ratings also predicted frequency of mention by other subjects asked to list parts of an object. The good parts, or for that matter, all the parts in these norms and in the attribute norms as well, are at the same level of analysis, the level of *seat* and *engine* and *wheel.* Subjects list parts, but not parts of parts. Appropriately configured, the parts listed form whole objects. Both perceptual salience and functional significance seem to play a role in goodness ratings. The best part of a chair is a *seat,* the best part of pants are *legs,* the best part of a saw is a *blade,* the best part of a piano is *keys,* and so on. In each of these examples, a case can be made that the best part is among the most perceptually salient and the functionally most important parts. Similarly, the parts receiving especially low ratings seem to be unimportant both to the perception of and the function of the object. The following examples illustrate this point: for lamp, the parts *gas, screws,* and *plastic;* for saw the *rust;* for lettuce, the parts *root, stem, dirt,* and *bug.* Another factor that appears to be correlated with part goodness is the prevalence of the part among the category members, or its essentialness. Optional or less essential parts, such as *stuffing* for chair and *radio* for car are viewed as less good parts than more prevalent and essential parts. Essentialness or prevalence seems to be related to functional significance; a chair without a *seat* wouldn't function as a chair, but a chair without *stuffing* would just be less comfortable. Ethnological evidence from universals in body-part naming corroborate these observations (Andersen, 1978; C. H. Brown, 1976). Body parts enjoying perceptual salience and functional significance are named earlier in the development of terminology and receive more distinctive names. A reasonable question to raise at this point would be, which contributes more to part goodness, perceptual salience, functional significance, or even frequency or essentialness. People could be asked to rate parts on each of these attributes separately, and those ratings could be correlated with goodness ratings. Examination of the goodness ratings discourages such an undertaking. Not only do perceptual salience and functional significance seem to be highly correlated themselves, but there is also an inherent ambiguity or duality in many of the part names themselves. To return to our old example, *seat* may refer to a perceptually distinct segment of a chair, but it also may refer to a distinct function.

For specially selected natural objects and for artificial objects, it seems possible to separate functional significance from perceptual salience. In artificial stimuli, there is usually no function to contend with. There is some evidence that for children, perceptual salience, particularly in the contour of an artificial object, highly determines parsing an object into its parts (Kosslyn, Heldmeyer, & Glass, 1980). Young children fail to notice parts of natural objects that are functionally significant but perceptually small (Tversky & Bassok, 1978). This suggests that perceptual salience will influence perceived goodness of part at an earlier stage of development or of knowledge acquisition than functional significance. Elsewhere (Melkman, Tversky, & Baratz, 1981) it has been argued that perceptual properties are more immediate than functional properties. Perceptual properties may be known simply from observation of a static object, but knowledge of functional significance, of behavioral properties, seems to require observation of an object in use or in motion.

Recently, there have been several interesting attempts to account for the way we parse forms into parts, usually phrased in terms of the geometry of the forms or the surface appearance of the objects (Bower & Glass, 1976; Hoffman & Richards, 1982; Kosslyn et al., 1980; Palmer, 1977). Local minima in contours, changes in color or texture, "wholeness" of the part (tendency toward closed contour) have been suggested as characteristics of forms that determine parsing. Parts obtained through these perceptual principles have consequences for other tasks: They are better cues to memory for the whole form (Bower & Glass, 1976); they are more quickly identified as being part of the whole (Palmer, 1977). In recent artificial intelligence models, they have played an important role in the structural descriptions of objects (Hoffman & Richards, 1982). All of this research has explored artificial stimuli, where perceptual properties are manipulated but where functional or behavior properties are absent. The connection of parts parsing to function has only now been suggested.

Many metaphoric extensions of parts labels are evident in the list of object parts. Labels for body parts are broadly extended: many objects have *arms, legs, feet, heads,* and *bodies.* Both perceptual and functional similarity to the anthropomorphic parts affect metaphoric extensions. The arms and legs of objects, for instance, are long, thin extensions of objects, arms usually exending from the middle, legs extending at the bottom. But, arms and legs of objects also serve a similar function in objects as in people, that of support (for both) and of manipulation (for arms, viz., *arm* of a phonograph). Some object part labels seem to derive from the human parts with which they interact. *Handles* may look and function like hands, but also, they are interacted with by hands, and shirt *backs* and chair *backs* are at the rear sides of objects, but also are interacted with by the *backs* of people.

GENERAL DISCUSSION

Review of Findings

In taxonomies of common objects and organisms, one level of reference appears to have a privileged status in many diverse cognitive tasks. This level, called the basic level (Rosch et al., 1976), has been identified primarily using a quantitative index of informativeness. Our work has demonstrated a qualitative difference in categories at the basic level and has offered an explanation for the convergence of so many measures at that level. We have shown that one type of knowledge is particularly salient at the basic level, namely, knowledge about parts. Names of parts frequently enjoy a duality not apparent in other attributes; they refer both to a perceptual entity and to a functional role. The *leg* of a chair or the *handle* of a screwdriver have a particular appearance, but they also have a particular function. The prevalence of parts in subjects' attribute lists appears to be particularly diagnostic of the basic level. When asked to characterize entities at the superordinate level, subjects produce few, if any, parts, even for biological categories. Relatively many parts are produced at the basic level, the majority of attributes listed. The proportion of attributes that are parts (and, for nonamended norms, the absolute numbers) decreases at the subordinate level. Thus, part terms play a special role in the vertical organization of categories, that of distinguishing the basic level of reference. Parts play a role in the horizontal organization of categories, too. Different subordinate entities belonging to the same basic level category are perceived to share parts and to differ on other attributes. Similarly, different basic level categories are seen to share other attributes and to differ from one another on the basis of parts. So, the natural breaks among basic level categories are between clusters of parts, but the natural breaks between subordinate or superordinate level categories are not based on parts. There is a horizontal organization or internal structure to the parts belonging to a particular object, as well. Parts differ in perceived goodness. Subjects agree on which parts of an object are relatively good parts of the object, and goodness is correlated with frequency of mention. Parts that are good appear to have both functional significance and perceptual salience, such as the *leg* of pants, or the *seat* of a chair. Good parts also seem to be shared by many category members and seem to have distinctive labels. None of these variables seems to be primary; rather, their intercorrelation seems to be a fact about the objects and organisms in the world.

Parts and the Convergence of Cognitive Tasks at the Basic Level

There is a long and growing list of cognitive tasks, reviewed earlier, that converge on the basic level. Some of these tasks reflect the appearance of objects, the way objects are perceived and represented. For instance, the basic level is the highest level of abstraction for which a generalized outline form can be recognized and the highest level for which an image can be generated. It is the level at which pictures of objects are identified most rapidly. Some of the tasks pertain to our behavior or responses to the objects, or, more teleologically, to the functions objects serve us. Thus, the basic level is the most abstract level for which motor programs directed toward the objects share elements. Some of the tasks relate to the way we label objects, to our communication about them. Thus, the basic level is the first level to be developed in the evolution of a taxonomy, and the level at which differentiations abound. Basic level terms tend to be shorter and more frequent than either more abstract or more specific terms. They are the terms first taught to and used by children.

Part configuration, we submit, forms the conceptual skeleton underlying and accounting for the convergence of so many different measures at the same level of abstraction. The configuration of parts, or structural description, accounts for the shapes objects may take, thus for our perceptual representations of the appearance of objects. When we interact with objects, our behavior is typically directed toward their parts. Different parts appear to have different functions, or to elicit different behaviors. We sit on the *seat* of a chair and lean against the *back*, we remove the *peel* of a banana, and eat the *pulp*. All other things being equal, entities distinguished in perception or behavior should also be distinguished in language, so breaks in communication should follow the natural breaks in perception. Our terms of reference are selected to pick out an entity in a context. Linguists have argued that basic level terms are contextually neutral (Cruse, 1977). So, saying, "Put out the dog" is fine, but when we say, "Put out the animal," we communicate something more than a simple request. Similarly, when we tell a friend we've acquired a new, pedigree, Hungarian straight-eared toy poodle, we convey something more than when we say we've gotten a new dog. Elsewhere (Tversky & Hemenway, 1983) we have argued that the ordinary context for an object is the scene in which it typically appears; scenes are, to a large degree, composed of basic level objects. So, *chairs* appear in houses and in schools and need to be distinguished from other objects appearing in those situations, particularly, other furniture. *Socks* appear in stores and houses and need to be distinguished from other objects appearing in those contexts, particularly, other clothing. Thus, parts and part configuration form a natural bridge connecting perception of objects and behavior toward them, and in turn, communication about them.

Two aspects of this argument are in need of elaboration. The first concerns the perceptual side, the second, the behavioral side. It might be argued that many of the tasks converging on the basic level concern the appearance, perception, and identification of objects, and that underlying these operations is simply the shapes of objects. Although shape undoubtedly contributes a great deal to the appearance, perception, and identification of objects, it simply does not go far enough. Shape is not unique. Objects are three-dimensional and appear to have different shapes from different points of view. Many objects have moving parts and appear differently in motion. Part configuration accounts for the different shapes objects may have when viewed from different perspectives and when in motion as well. Many of the parts subjects regard as good parts of objects are enclosed parts, with no consequences for the shapes of objects. These enclosed parts, however, can affect appearance without affecting shape (e.g., the *screen* of a television set) and frequently have important functions. Will a television without a screen or a bureau without drawers be easily and reliably identified? And, only the Tin Woodsman could function without a heart. Shapes, too, cannot account for behavioral measures. Finally, other kinds of categories, such as scenes and events, have parts or components, but do not have shapes, so an analysis based on parts can be generalized to other hierarchies, whereas an analysis based on shape cannot. For these reasons, we believe parts and part configuration to be a more powerful theoretical concept than shape.

Others have argued that the proliferation of sensorial attributes distinguishes the basic level (Denis, 1982; Hoffmann, 1982). Of course, most sensorial attributes are parts, and most parts are sensorial, making it difficult to decide between them. The notable exceptions are internal parts, which are not sensorial, and colors, which are not parts. Would a lemon still be a lemon if it weren't yellow? If it didn't have pulp? Would a fire engine be a fire engine if it weren't red? If it didn't have an engine? Like shapes, sensorial features bear no relation to function and an account of the basic level based on sensorial features cannot be generalized to nonperceptual categories. For some tasks that depend on speeded visual recognition, there may be an advantage to color over internal parts, though for many objects and organisms, color is not a distinguishing feature at all. For other tasks, such as those that depend on function, uses, behavior, or relations to other categories, internal parts seem more important. Thus, sensorial features that are not parts may be more important in the identification procedure associated with a concept, whereas parts may be more important to the conceptual core (Smith & Medin, 1981).

Now, some comments on parts and function. The motor program norms collected by Rosch et al. (1976) used objects, mostly manufactured, as stimuli. These norms reflect human interaction with objects designed for human use. But, parts and function, or parts and behavior seem to be related independent of human users. Thus, the leaves and trunk of a tree have different functions for the tree, the legs and trunk of an elephant behave differently and have different functions for the elephant. Because cars are inanimate, we are less likely to talk about the function of the wheels or engine for the car, but we can say that these different parts of the car are associated with different behaviors. So we would like to argue that parts underlie function for human users, but that they are also related to functions or behaviors in a nonteleological sense, regarding the organism or object as a closed, self-contained system.

Parts and Other Kinds of Categories

Part configuration is especially important because of its role as a bridge between appearance and activity, between perception and behavior, between structure and function. Because structure is related to function via part configuration, part configuration underlies the informativeness of basic level categories. Is the prevalence of parts diagnostic of a privileged level in nonobject categories and hierarchies? Categories of scenes have a basic level, characterized by a proliferation of parts (Tversky & Hemenway, 1983). There is some preliminary evidence for a basic level in categories of events (Rosch, 1978; Rifkin, 1981), or scripted activities. Events, too, can be said to have parts or components. Eating at a restaurant, then, is composed of being seated, ordering food, eating, paying, and leaving. Note that the components of the restaurant script differ perceptually as well as functionally. More generally, it may be the case that perceived part structure is the basis for a privileged status in a taxonomy, that without a level of abstraction where component structure is particularly salient, there will not be a basic level of categorization where so many varied tasks and operations converge.

Parts and Principles of Categorization

The basic level of reference is the starting point for building a taxonomy both phylogenetically, in a community of speakers of the same language (Berlin, 1978), and ontogenetically, in the developing speech of children (Clark, 1983; Mervis & Crisafi, 1982). There are indications that the principles of classification are not the same at other levels. Rosch and her colleagues (Rosch et al., 1976) have argued that category cuts are determined by the structure of the world. Primary cuts are made at the basic level because, for this level in particular, attributes are correlated. Our work suggests that part configuration, because of its role in relating structure, function, and communication, underlies the correlated attributes or high cue validity present at the basic level. Unlike many categories at other levels, basic level categories seem to be mutually exclusive. Entities seem to belong to no more than one basic level category, though they may belong to more than one superordinate or subordinate category. Subordinate categories, in fact, seem to be designed to cross-classify members of basic object categories. So we have straight-leg pants that may or may not be denim pants and also may or may not be striped pants and even may or may not be wash-and-wear pants. Kitchen chairs may be wooden chairs and may be armless chairs and may be Breuer chairs. Moreover, in general, straight-leg pants and wooden chairs differ from other pants and chairs only on that single feature. The principles governing the construction of subordinate categories in artifacts do not seem to be principles of mutual exclusion. Of course, biological categories are necessarily mutually exclusive, but human beings frequently destroy their elegance by using such categories as farm animals or shade trees or drought-resistant flowers or tropical fish, that cross-cut the biologically rooted categories. In a less flagrant way, superordinate categories can also violate mutual exclusion. Cars and roller skates may be vehicles as well as toys. Knives may be tools and weapons and kitchen utensils. A recorder may be a musical instrument and a toy. We do not balk at these exceptions to mutual exclusion. Not so for basic level concepts. Something isn't both a cantaloupe and a ball. It can be a cantaloupe that looks like a ball, or a ball that looks like a cantaloupe, but isn't both. Sometimes, at the boundaries, it's hard to tell the cups from the mugs or the stools from the chairs, but these are recognized as marginal examples, where both appearance and function are similar. Knives, however, are central tools and central kitchen utensils and central weapons. In folk taxonomies (Berlin et al., 1973), the basic level is the first and most richly differentiated. Other levels are differentiated later, but optionally. Young children, too, appear to break up the world's objects and organisms on one level, the basic level, and show resistance, verbally and conceptually, to higher level categories that include more than one basic level category (Clark, 1983; Inhelder & Piaget, 1964). Children find part–whole relations easier than class inclusion (Markman, 1981), which may explain why their first classifications are at the basic level.

Thus, for object and biological categories, primary or basic category cuts seem to follow natural breaks in the correlational structure of attributes in the world. These breaks, we have argued, are determined by part configuration. Grouping and differentiation at other levels of abstraction need not follow the same principles as categorization at the basic level. Basic categories come first, and are based primarily on parts. Then, we form higher-order, superordinate groupings, that are typically based on function, not perception, where function is rather abstractly conceived. At the same time, we also subdivide basic level categories into more specific categories, on the basis of one (or very few) perceptual or functional features. In contrast to basic level categories, both more general and more specific categories do not have a basis in part configuration, nor do they always conform to mutual exclusivity.

Taxonomy and Partonomy

Sedans and station wagons are kinds of automobiles, while engines, wheels, and doors are parts of automobiles. Both these relations, *kind of* and *part of,* are asymmetric and transitive and can form hierarchies (Miller & Johnson–Laird, 1976). Hierarchies of kinds form the familiar object and organism taxonomies where lower levels are related to upper levels by class inclusion. Hierarchies of parts form partonomies. A familiar one is the body part partonomy, where body is divided into head, trunk, arms, and legs, and each of these is, in turn, divided into its subparts. Abstract concepts can also be represented as partonomies. In eighth-grade civics, for instance, we all learn that the government consists of legislative, judicial, and executive branches, each of which is further divided into its subcomponents. Taxonomies have been recommended for their cognitive economy (e. g., Collins & Quillian, 1969); not only do they provide a structure for a large body of knowledge, reducing the number of categories with which we ordinarily need to deal, but they also generally allow inference of properties from higher level nodes to the categories included in them. If having wheels or running on land are properties of cars, then we can infer that they will hold for any kind of car. In general, *part of* relations do not allow such inference; it is not the case that all parts of cars have wheels or run on land.

Parts and Naive Induction

Part configuration seems to serve a very different role in the organization of knowledge. Put directly, part decomposition appears to be a way of relating structure to function. Our exploration of goodness of part led us to the conclusion that parts that are perceived to be good are, in general, those that enjoy both perceptual salience and functional significance. This intuition, in fact, seems to be the basis for naive induction, for initial mental models of the physical (and metaphysical) world, for intuitive science. Preliminary investigations of many phenomena are often guided by these working assumptions: that separate parts will have separate functions, that similar parts will have similar functions, that more salient parts will have more important functions, that, together, parts form an organized, integrated, functioning whole. These initial assumptions may turn out to be wrong, but they nevertheless characterize initial explorations. Biology abounds with examples where structural parts guided the search for function. Phrenology, where separate parts of the skull were assumed to have separate cognitive functions, stands as a classic example of a failure of this approach. But it was eventually replaced by neuroanatomy, which has succeeded in relating different brain structures to different cognitive functions. In his dramatic account of the revolution in microbiology, Judson (1979) showed how at many stages, new techniques for "seeing" structure and determining components led to major advances in the discovery of function. In their rudimentary, intuitive attempts to account for physical phenomena, children, too, often explain function or behavior by reference to parts, of objects, situations, or events (for instance, Bullock, Gelman, & Baillargeon, 1983). Our mental models for comprehending physical systems typically divide them into separate parts having separate functions (see examples in Anderson, 1981, and Gentner & Stevens, 1983). Designers of complex systems for human use, such as computer systems, are often explicitly advised to conform to these working assumptions, of separate parts for separate functions, of similar parts for similar functions, of large parts for important functions, and so on (Norman, 1982). Perceived part configuration, then, underlies both perceived structure and perceived function. As such, it seems to form the basis for intuitive causal reasoning and naive induction.

We began with Caesar's campaign on Gaul, with the observation that in describing or comprehending some body of knowledge or set of phenomena, we often begin by decomposing the thing to be understood into separate parts. This "divide-and-conquer" strategy is invoked not just because smaller parts are easier to deal with, but also because different parts are to be dealt with differently. Each part has a different story. How does this relate to the phenomenon of a basic level, to a preferred level of reference or abstraction, to a level more informative than others, to a level where the primary categories of objects and organisms, scenes and events are carved out? Our work has shown that one particular kind of information is more salient in the minds of people when they think about entities at the basic level, namely, information about parts. Through parts, we link the world of appearance to the realm of action. Through parts, we use structure to comprehend, infer, and predict function. This, then, seems to be the knowledge that makes the basic level the most informative level: the knowledge of function that can be inferred from structure.

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(Appendixes follow on next page)

Appendix A

Table A1
Attributes Included in Judge-Amended Tally for Some Biological Categories at Three Levels

Category	Parts	Nonparts
Animal	Tail Eyes	Moves Living Eats
Bird	Two legs Wings Feathers Beak	Lays eggs Living Builds nests Eats Moves
Chicken	Two legs Wings Feathers Beak	Brown Lays eggs Eats worms Living Eaten by humans Builds nests Eats Moves
Robin	Two legs Wings Red breast Feathers Beak	Chirps Flies Lays eggs Eats worms Small Living Builds nests Eats Moves
Fish	Tail Fins Eyes Gills Scales	Moves Living Eats Swims
Goldfish	Tail Fins Eyes Gills Scales	Small Orange Moves Living Kept in small bowl Swims Eats
Salmon	Tail Fins Eyes Gills Scales	Used in salads Comes in cans Moves Lives in streams Living Used in sandwiches Swims Eats Swims upstream Ocean
Plant	Stem Roots	Needs carbon dioxide Needs water Green
Flower	Petals Stem Leaves	Needs carbon dioxide Needs water Pretty Green
Rose	Petals Thorns Stem Leaves	Needs carbon dioxide Needs water Red Pretty Yellow Grows on bushes Colorful Pink
Poppy	Petals Stem Leaves	Needs carbon dioxide Needs water Pretty California state flower Opium White Colorful
Tree	Bark Trunk Wood Branches Roots	Green Needs carbon dioxide Needs water
Palm tree	Trunk Leaves Coconuts Wood Branches Branches all at top Roots Bark	Warm climate Green Large Tall Needs carbon dioxide Needs water Very tall
Pine	Trunk Wood Branches Roots Needles Cones Bark	Green Large Tall Needs carbon dioxide Forest Needs water Fragrant Very tall Used for furniture

Appendix B

Table B1
Selected Mean Goodness Ratings of Parts of Objects

Part	*M*	Part	*M*
Clothing: Pants			
Leg	1.9	Snaps	3.9
Pockets	2.1	Inseam	4.0
Seat	2.2	Hem	4.3
Zipper	2.5	Buttons	4.3
Material	2.6	Label	4.5
Crotch	3.1	Stitching	4.6
Waist band	3.1	Bell bottoms	4.6
Belt loops	3.4	Cuff	4.8
Belt	3.7	Elastic	4.9
Thread	3.7	Patches	5.3
Seam	3.9		
Furniture: Chair			
Seat	1.6	Cloth, material	3.1
Arms	1.9	Legs	3.3
Back	2.2	Foot rest	3.5
Cushion	2.3	Leg rest	3.5
Back rest	2.4	Wood	3.5
Arm rests	2.5	Stuffing	3.6
Upholstery	2.9	Feet	4.7
Head rest	3.0	Buttons	5.9
Musical instruments: Piano			
Keys	1.1	Legs	3.4
Keyboard	1.1	Wood	3.5
White keys	1.2	Cover	3.8
Black keys	1.5	Lid	4.1
Music	1.7	Music stand	4.3
Pedals	1.8	Screws	4.7
Strings	1.9	Brand name plate	4.7
Hammers	2.7		
Bench	2.9	Hinges	4.7
Wood body	3.0	Wheels	5.8
Stool	3.1		
Tools: Saw			
Blade	1.1	Handle	2.6
Sharp teeth	1.2	Motor	3.3
Tools: Saw (*continued*)			
Metal blade	1.5	Wood (parts)	4.0
Teeth	1.9	Screws	4.3
Metal	2.3	Rust	6.2
Vegetables: Lettuce			
Head	1.0	Core	4.5
Green	1.8	Root	5.3
Leaf	1.8	Stem	5.5
Cellulose	3.2	Dirt	6.5
Water	3.5	Bug	6.7
Vein	3.8		
Vehicles: Car			
Engine	1.5	Mirror	2.7
Steering wheel	1.6	Chassis	2.7
Brakes	1.6	Lights	2.8
Wheels	1.9	Axle	2.8
Seats	1.9	Speedometer	2.9
Tires	2.0	Side view mirror	2.9
Headlights	2.1	Radiator	2.9
Transmission	2.1	Hood	3.1
Gear shift	2.1	Horn	3.1
Windshield	2.1	Fender	3.3
Pedals	2.2	Exhaust pipe	3.3
Pistons	2.3	Spare tire	3.4
Carburetor	2.3	Roof	3.6
Fuel tank	2.3	Dashboard	3.6
Gasoline	2.3	Trunk	3.6
Battery	2.4	Radio	3.7
Spark plugs	2.5	Door handles	3.9
Rearview mirror	2.5	Paint	4.0
Drive shaft	2.5	Glove compartment	4.1
Seat belt	2.5		
Body	2.6	Hubcaps	4.4
Bumpers	2.6	Carpeting	4.7
Window	2.7	Rugs	4.8
Wipers	2.7	Handle	4.9
Door	2.7		

Received March 25, 1983
Revision received September 1, 1983 ■