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Cognitive Representations of Semantic Categories

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SUMMARY

The technique of priming was used to study the nature of the cognitive representation generated by superordinate semantic category names. In Experiment 1, norms for the internal structure of 10 categories were collected. In Experiments 2, 3, and 4, internal structure was shown to affect the perceptual encoding of physically identical pairs of stimuli, facilitating responses to physically identical good members and hindering responses to physically identical poor members of the category. Experiments 5 and 6 showed that the category name did not generate a physical code (such as lines and angles) but rather affected perception of the stimuli at the level of meaning. Experiments 7 and 8 showed that while the representation of the category name which affected perception contained a depth meaning common to words and pictures which enabled subjects to prepare for either stimulus form within 700 msec, selective reduction of the interval between prime and stimulus below 700 msec revealed differentiation of the coding of meaning in preparation for actual perception. Evidence from these experiments indicated that pictures could be prepared for more rapidly than words. Experiment 9 demonstrated that good examples of semantic categories do not appear to be physiologically determined, as the effects of the internal structure of semantic categories on priming (unlike such effects for color categories) could be eliminated by long practice.

From this series of experiments, four basic findings can be derived. First, the internal structure of superordinate semantic categories was clearly a pervasive aspect of the way in which those categories were processed in the tasks used, a result which does not depend for its validity on any particular interpretation of the meaning of internal structure. Second, the results supported the claim that there are different levels of processing in perception. The meaning of superordinate category terms appeared to affect the perception of some pairs of stimuli, but not at the level of concrete features. Third, the set of experiments allowed some conclusions about the underlying representation of superordinate categories. A depth meaning of these categories did not appear to be specifically coded in terms of words or pictures; rather, that depth meaning appeared to be translated into a format in preparation for actual perception which differed slightly for words and pictures. The fact that less time was required to prepare for pictures suggests that pictures may be closer to the nature of the underlying representation than are words. Fourth, the research made possible a comparison of representations of superordinate categories with other kinds of categories (such as color which is coded quite concretely) and with categories at other levels of abstraction, thereby providing a method for collecting data concerning many unresolved issues in the nature and development of abstraction.

When we hear a category word in natural language such as *furniture* or *bird* and understand its meaning, what sort of cognitive representation do we generate? A list of features necessary and sufficient for an item to belong to the category? A concrete image which represents the category? A list of category members? An ability to use the category term with no attendent mental representation at all? Or some other, less easily specified, form of representation?

The nature of cognitive representations of semantic categories has direct relevance to two important areas of psychological inquiry: One concerns the structure of categories and concepts and has implications for the way in which concepts and concept attainment should be studied in psychological research (Rosch, 1973, in press-a, in press-c). The other area is the nature of mental representations in general, a prominent concern in the postbehaviorist study of mental events (Cooper & Shepard, 1973; Posner, 1973; Segal, 1971).

The present research was designed to investigate both issues within the same series of experiments. The first four experiments focused on the question of the nature and structure of categories and the effect of that structure on the tasks used. The succeeding five experiments used the effects of internal category structure found in the first experiments (reliable empirical effects which did not depend on any particular, possibly controversial, interpretation of internal structure) to explore several more general questions concerning the nature of mental representations of categories: questions regarding the type and degree of concreteness of the representations, and questions regarding the presence or absence of differentiation of the representations into pictorial and verbal forms.

With respect to the issue of the nature of categories, Rosch has previously argued (Rosch, 1973, 1975, in press-c) that many traditions of thought in philosophy, psychology, linguistics, and anthropology imply that categories are Aristotelian in nature—that is, that categories are logical, clearly bounded entities, whose membership is defined by an item's possession of a simple set of criterial features, in which all instances possessing the criterial attributes have a full and equal degree of membership. While such a structure may, in fact, characterize the artificial categories employed in much concept formation research (Bourne, 1968) and research on artificial languages (Ginsburg, 1966), many natural categories, that is, concepts designatable by words in natural languages, appear to possess structures of a quite different character (Labov, 1973; Lakoff, 1972; Rosch, 1973). The domain which has most readily lent itself to the demonstration of a type of categorical structure contradictory to the Aristotelian is that of color. There is now considerable evidence that color categories are processed by the human mind (learned, remembered, denoted, and evolved in languages) in terms of their internal structure; color categories appear to be represented in cognition not as a set of criterial features with clear-cut boundaries but rather in terms of a prototype (the clearest cases, best examples) of the category, surrounded by other colors of decreasing similarity to the prototype and of decreasing degree of membership (Berlin & Kay, 1969; Heider, 1971, 1972; Mervis, Catlin, & Rosch, 1975; Rosch, 1973, 1974, 1975, in press-c, in press-d).

Color, however, is a perceptual domain; its categorization is probably physiologically based (McDaniel, 1972; Rosch, 1974, in press-b, in press-d). Not all categories have an obvious perceptual basis and many categories may be culturally relative. Is the concept of internal structure applicable to other types of categories?

At this point, it is necessary to elaborate on the logic of the concept of internal structure as it is used in the present research. The hypothesis that categories have internal structure is not a theory which specifies, in advance of the collection of data, a precise model (with flow charts, steps, etc.) which is then tested by means of data from particular tasks. Rather, internal structure refers to that general *class* of conceptions of categories in which categories are not represented only as criterial features with

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clear-cut boundaries and in which items within categories may be considered differentially representative of the meaning of the category term. Progressive clarification of the meaning of internal structure is intended to occur through operational definitions based on converging experiments. Furthermore, initial experiments are intended to be in the form of "class questions" (Are categories of the general form x or y?) rather than in the form of tests of specific stimulus or processing models. The research reported in this article (and in Rosch's other articles on the nature of human categorization which are referred to throughout this article) provides illustrations of this strategy of conducting research.

This article is concerned with the question of whether the general concept of internal structure, previously specified only for perceptual domains such as color and form, is applicable to other types of categories; specifically, whether it is applicable to the semantic classifications of common objects in everyday use. Applicability refers to two general issues: Can subjects make meaningful judgments about internal structure—the degree to which instances are good or poor members of categories; and can a reasonable case be made that internal structure affects cognition with respect to categories?

Some evidence that semantic categories fulfill both criteria for internal structure already exists. Rosch (1973) showed that subjects reliably rated the extent to which an item represented their idea or image of the category name for six items from each of eight categories. Such ratings were predictive of subjects' reaction times in a sentence verification task of the form "A (member) is a (category)" (Rosch, 1973). Rips, Shoben, and Smith (1973) confirmed and extended Rosch's (1973) findings, and Smith, Shoben, and Rips (1974) have argued that a model based on ratings and sentence verification tasks such as these can account for most of the findings in the literature on retrieval from semantic memory.

With regard to the nature of categories, the purpose of the present research was to extend the range of processing tasks shown to be affected by category structure and, thus, elaborate further the concepts of category structure and prototypes. It should be emphasized that the research was designed to investigate the nature (the structure and content) of cognitive representations of semantic categories, not the dynamic processes (activation, spread of energy, evaluation of paths, etc.) by which those representations are formed. That is, the studies were designed to focus on the *what* and not the *how* of cognitive representations of semantic categories. Specifically, the present research was not an attempt to construct a model of semantic memory; the fitting of dynamic memory models to the data of the present research is seen as a further stage of investigation. In Experiment 1, norms were collected for ratings of the goodness of example of a large number of instances from 10 systematically chosen classifications of common concrete objects. Succeeding experiments explored the manner in which those ratings of internal structure affected outcomes in tasks which were designed to explore aspects of the structure and content of cognitive representations of categories.

With regard to more general questions about the nature of mental representations, these issues have been the subject of philosophical and psychological debate since the initiation of both fields of study. The present research was concerned with a specific type of category—the higher-level (superordinate) classifications into which the common concrete objects of our culture are divided—and with some of the classic questions concerning the nature of mental representations as these can be applied to such categories. Do our cognitive representations involve concrete imagery as Titchener (1909) claimed, or, as the Wurzburg school countered, is thought essentially abstract and imageless; do all meanings have a common abstract form regardless of their content, or are meanings represented in a variety of modes, for example, by different forms of representation for verbal materials and for pictures (Boring, 1950)? The purpose of the present studies was to obtain data relevant to these interesting issues.

The questions that can be asked and the kinds of answers that can be obtained about the nature of mental representations of categories depend upon the particular research procedures by which representations are studied. The present studies are based on a method of priming (Beller, 1971) in the type of matching paradigm described by Posner and Mitchell (1967), which Rosch (in press-d) had already demonstrated to be particularly suitable to a study of the nature of the mental representation of color categories.

In the original matching research, subjects were required to decide as rapidly as possible whether two simultaneously presented visual letters were the same or different; under some conditions *same* was defined as physical identity (e.g., AA), and under others as possession of the same name (e.g., Aa). If a subject is provided with some of the information which he needs to make the match in advance of presentation of the pair, matching speed should be facilitated. Beller (1971) primed subjects with a letter (the letter was presented 2 sec in advance of the pair) and found that physically identical, as well as same-name, pairs improved—even when physically identical pairs were in the opposite case from the case presented in the prime (e.g., if the prime was A, the pair aa, as well as AA, was facilitated). Posner (1969) argued that this showed that subjects were not simply retaining a literal representation of the presented letter but were generating an abstract expectation or representation which did not depend on case. It should be noted, however, that, as in early studies of set (Haber, 1966), this reasoning assumes that, because the prime is presented prior to the stimulus, it must have its influence on cognitive processes which occur prior to—rather than during or after—presentation of the stimulus.

The basic logic of the priming technique as it was used by Rosch (in press-d) and as it is used in the present experiments, is that a prime can only facilitate a response if it contains some of the information needed to make the response. If the prime facilitates a response when the prime is presented prior to the stimulus but not when presented simultaneously with the stimulus, it can be inferred that the information which facilitates the response is located in the representation generated by the prime in advance of information provided by the stimulus. If, under such conditions (i.e., a prime is effective when presented prior to, but not simultaneously with, a stimulus), a prime affects reaction time to physically identical pairs of stimuli, it may be concluded that the representation generated by the prime contains some of the information used by subjects in the perceptual encoding of the stimulus.[1] Since it is assumed that no facilitation occurs if the representation has not been allowed sufficient time to develop, it is possible to assess the amount of time taken to generate the representation by systematically reducing the length of time between the prime and the stimulus until the prime loses its effectiveness.

There is another possible outcome in which the effects of priming may include a different process. A prime may be effective when presented simultaneously with a stimulus as well as when presented prior to the stimulus. In such cases, it can be inferred that at least part of the relevant information in the prime acts on decision processes regarding the stimulus after the stimulus is available to the subject. However, because of possible interactions between stages of processing (see, e.g., Sternberg, 1969), it may be impossible to determine, from a priming experiment alone, which processing events are affected and in what manner by the prime.

A study of colors (Rosch, in press-d)

[1] We may make such an assumption because the only operations which a subject can perform upon a physically identical pair are (a) the perception (visual encoding) of the stimuli and (b) the perception that the members of the pair are identical. Even if the perception of physical identity is a decision separate from perceptual encoding of the stimulus itself, a prime consisting of a category name does not contain within it information about the nature of identity as such (an especially untenable assumption if, as was found to be the case, the prime differentially affects different types of stimuli). Thus, the only possibility, under these conditions, is that the prime affects the visual encoding.

illustrates how results found by priming can be of direct relevance both to the nature of color categories and to the nature of cognitive representations. Advance priming with the category name facilitated responses to good examples of color categories and hindered responses to poor examples for physically identical pairs of colors both under instructions which defined *same* as belonging to the same category and under those which defined *same* as physical identity. The selective effect of the prime was entirely eliminated by simultaneous presentation of prime and stimuli. Following the previous logic, it was concluded that the cognitive representations of color category names contained information used in the perception of actual color stimuli. Furthermore, since the effect of the prime was selective, it could be concluded that the internal structure of color categories affected the representation generated by the category name; that is, the representation appeared to contain information used in the perception of good members of color categories but which was sufficiently unlike poor members of the category as to interfere with their perception. Representations of color categories were generated quite rapidly—selective effects of priming were already significant at 200 msec, which is less than half the time usually estimated to be required for the formation of a visual image (Posner, Boies, Eichelman, & Taylor, 1969). In sum, the effectiveness of the priming technique for an investigation of cognitive representations demonstrated by Rosch's (in press-d) studies of color categories made reasonable the present attempt to use a similar logic and similar procedures for an investigation of cognitive representations of semantic categories.

The nine experiments of the present research were designed to form a logical sequence. In Experiment 1, reliability of subjects' ratings of internal structure was verified, and norms were collected for ratings of the goodness of example of 50–60 members of 10 systematically chosen categories. In Experiment 2, items (represented by pictures in one condition and by words in another condition) of high, medium, and low goodness of example, according to the norms provided by Experiment 1, were used in a priming study with a 2-sec interval and same-category instructions. The conditions of Experiment 2 were designed to determine whether, under maximally favorable conditions, any effect of internal category structure on the representation of the category could be observed. Experiment 3 was performed to check whether effects obtained in Experiment 2 were the artifactual result of the fact that subjects did not consider the poor examples of the categories members of those categories at all. Because an interaction between goodness of example and priming was achieved in Experiment 2 which did not appear to be an artifact, Experiment 4 was performed in which essential aspects of Experiment 2 were replicated under conditions in which the prime and stimulus were presented simultaneously. Following the logic previously outlined, the results of Experiments 2 and 4 indicated that the effect of internal structure on same category and different responses lay partially in the decision processes after the stimulus pair was presented and that, in those conditions, effects of the prime on encoding and on subsequent decisions could not be unequivocally disentangled. However, the effects of the prime on physically identical pairs in these experiments showed a selective effect of the representation generated by the category name prior to presentation of the stimulus—an effect very similar to that which had been found for colors by Rosch (in press-d).

Subsequent experiments focused on obtaining further information about the nature of the representation as it appeared to affect physically identical pairs when the prime was presented prior to the stimulus. In Experiment 5, physical identity instructions were employed to test the concreteness of the representation; the disappearance of the effects of advance priming under such instructions indicated that different levels of encoding of the stimuli were being used. This hypothesis was further verified by a recall task in Experiment 6. Experiment 7 approached the question of whether the meaning which appeared to be part of the representation generated by the category name was differentiated into pictorial and verbal form. In this experiment, both pairs of words and pairs of pictures were used as stimuli for the same subject, presented in a format such that subjects were uncertain about the form of the stimulus pair with which they would be presented on each trial. The results for Experiment 7 did not indicate a differentiation of the code for words and pictures. However, since the length of the 2-sec prime interval may have masked subtle degrees of such differentiation, Experiment 8 was performed to chart the time course of generation of word and picture representations both under conditions in which the form of the ensuing stimulus was certain and uncertain. This experiment produced some evidence of differentiation of representations required in processing verbal and pictorial form, and some evidence that representations for pictures were generated more rapidly than those for words. The final experiment was designed to study the effect of long practice and thorough memorization on a small set of good and poor examples of categories.

Experiment 1

Before attempting to examine the effect of internal structure on mental representations of semantic categories, it was necessary to establish the reliability of judgments of internal structure for these categories. That is, it was necessary to gather reliable normative data on subjects' ratings of the extent to which instances of semantic categories represent their idea or image of the meaning of the category name. In addition, if the nature and extent of concreteness of representations were to be explored, it was necessary to use concrete, picturable categories in the studies. Previous subjects' ratings of internal structure (Rosch, 1973) were performed on only six items per category which had been prechosen to represent an expected wide range in goodness of example. Furthermore, the categories used in that study had not been systematically chosen and included abstracts as well as concrete categories. Rips, Shoben, and Smith (1973) used 12 instances of three categories for their basic material. The purpose of the present experiment was to determine reliability of ratings and gather normative data for a systematically sampled set of concrete noun categories in common use in English. If reliable, these norms were intended for use in the subsequent experiments on the nature of mental representations.

Method

Stimuli

The categories for which ratings of instances were to be gathered were chosen in the following manner: The population of categories of concrete nouns in common use in English was determined by drawing all concrete nouns with a word frequency of 10 or greater from the Kučera and Francis (1967) sample of written English. A category was considered in common use if at least five items from the category appeared in that list. A category was considered concrete only if the items in it could be unequivocally represented by pictures—thus, common categories such as *relative* or *number* were not considered concrete. Categories were eliminated if (a) the items bore a part–whole relationship to the only reasonable superordinate (e.g., parts of the body, parts of buildings), (b) if there was linguistic ambiguity among possible superordinates (e.g., *animal* is commonly used as a synonym for *mammal*), and (c) if the superordinate crosscut a large number of other taxonomic structures (e.g., *food*). Surprisingly, only 17 concrete categories met the initial frequency requirement, 7 of which were eliminated by the other criteria. The remaining 10 categories which were used in the normative study were: fruit, bird, vehicle, vegetable, sport, tool, toy, furniture, weapon, and clothing.

All of the categories which met the criteria were categories which had been included in the Battig and Montague (1969) normative tabulations of the frequencies with which instances were produced in response to the category name (e.g., all of the *tools* appear in the Battig & Montague norms under carpenter's tool). Thus, the Battig and Montague lists could be used as a basis for selecting those members of the categories which were to be rated in the present experiment. For each category, all of the items which had been produced by 10 or more subjects in the Battig and Montague study were included. Additional items to make a total of 50–60 instances were taken randomly from the items produced by fewer than 10 subjects in the Battig and Montague norms. Items that were jokes or obvious mishearings of the category name were excluded.

Subjects

Subjects were students in three psychology classes who filled out the rating forms as part of their class work. On a front sheet, subjects listed their country of birth and the country(ies) or state(s) in which they had lived since birth. Subjects who were not native speakers of English or who did not complete the forms were eliminated from the study. Analysis was based on the forms of the 209 remaining subjects.

Procedure

All members of a category were listed below the category name. Subjects were asked to rate, on a 7-point scale, the extent to which each instance represented their idea or image of the meaning of the category term. Specific instructions were:

> This study has to do with what we have in mind when we use words which refer to categories. Let's take the word *red* as an example. Close your eyes and imagine a true red. Now imagine an orangish red . . . imagine a purple red. Although you might still name the orange red or the purple red with the term *red,* they are not as good examples of red (as clear cases of what *red* refers to) as the clear "true" red. In short, some reds are redder than others. The same is true for other kinds of categories. Think of dogs. You all have some notion of what a "real dog," a "doggy dog" is. To me a retriever or a German shepherd is a very doggy dog while a Pekinese is a less doggy dog. Notice that this kind of judgment has nothing to do with how well you like the thing; you can like a purple red better than a true red but still recognize that the color you like is not a true red. You may prefer to own a Pekinese without thinking that it is the breed that best represents what people mean by dogginess.
>
> On this form you are asked to judge how good an example of a category various instances of the category are. At the top of the page is the name of a category. Under it are the names of some members of the category. After each member is a blank. You are to rate how good an example of the category each member is on a 7-point scale. A 1 means that you feel the member is a very good example of your idea of what the category is. A 7 means you feel the member fits very poorly with your idea or image of the category (or is not a member at all). A 4 means you feel the member fits moderately well. For example, one of the members of the category *fruit* is *apple.* If *apple* fit well your idea or image of *fruit,* you would put a 1 after it; if *apple* fit your idea of *fruit* very poorly you would put a 7 after it; a 4 would indicate moderate fit. Use the other numbers of the 7-point scale to indicate intermediate judgments.
>
> Don't worry about why you feel that something is or isn't a good example of the category. And don't worry about whether it's just you or people in general who feel that way. Just mark it the way you see it.

Approximately half (116) of the subjects received one random order of instances under the category name; the other half a different random order. Categories were typed on separate pages and each subject received a different order of categories (taken randomly from the 10! possible orders of 10 categories).

Results and Discussion

Rank orders and mean ratings of goodness of example for all instances of all categories are shown in Table A1. To test the reliability of ratings both Spearman rank-order correlations and Pearson product-moment correlations of the mean ratings were obtained (a) between split halves of the sample of subjects divided at random, (b) between subjects who rated the two different item orders, and (c) between subjects who had lived predominantly on the west ($n = 131$) versus east ($n = 78$) coasts of the United States. Consistency was extremely high. All split-half correlations were .97 or higher, and all correlations between the west and east coast samples were .92 or higher. Agreement between subjects was particularly high for the items rated as very good examples of the category; for example, for 9 of the 10 categories, 95% of the subjects agreed in giving the item with the mean best example rating the same score, that of 1. In addition, 6 categories occurred in both the present study and in Rosch (1973), making it possible to compare the rank order of the ratings which items received when they were the only 6 instances of the category present and when they were embedded in almost the total Battig and Montague (1969) list; for all 6 categories, all rank orders were identical.

The results of this study clearly indicate that semantic categories do have internal structure: (a) Subjects consider it a meaningful task to rate members of such categories according to how well they fit the subjects' idea or image of the meaning of the category name and (b) there is high agreement between subjects concerning these rankings.

Two precautions are necessary in the interpretation of the data, however. First, the internal structure that exists in the above senses does not entail any particular interpretation of the meaning of that structure. Nor was the present research designed to examine the relationships between the structure of categories obtained by the present instructions and structures obtained by other methods such as those of Battig and Montague (1969). Experiment 1 simply provides a reliable measure of internal structure (derived from instructions given to the subjects which incorporated the view of the nature of internal structure elaborated in the author's past work) which can be used in the subsequent studies of mental representations of categories. Second, the norms were collected on a somewhat restricted sample of subjects: college students enrolled in psychology classes. However, no claim is made that the internal structure of semantic categories should be universal for all cultural groups. What is important for the present study (and for other studies that might wish to use the present normative data) is that the population on which these norms were collected is the same population on which further experiments using the norms as an independent variable were performed. The normative data of Experiment 1 can thus be used as the basis for examining whether internal structure of semantic categories affects mental representations of the categories.

Experiment 2

The most basic rationale for use of the priming technique is that a prime can only facilitate a response when it makes possible generation of a mental code which contains within it some of the information needed to make the response. If the representation generated by a semantic category name is similar to a list of criterial attributes or in some other way represents only a common denominator of category membership (of inclusion within the boundaries of the category), *same* responses to pairs of items of any degree of category membership should be facilitated equally by priming with the category name. On the other hand, if the mental code is more like a representation of a prototype or best example of the category or in some other way includes information about the internal structure of the category as part of the mental representation of the category, *same* pairs of good examples should be more strongly facilitated by the prime than *same* pairs of poor examples.

Experiment 2 was performed to test whether there are any differential effects on priming ascribable to level of goodness of example—operationally, whether any significant interaction would be achieved between priming and level of goodness of example. The instruction condition used was that in which *same* was defined as belonging to the same category since it appeared likely that for semantic categories the greatest processing of meaning, and hence the greatest likelihood of the desired effect, would occur in this condition.

Method

Subjects

Subjects were 60 students in introductory psychology courses who received course credit for their participation. In this and all subsequent experiments, only native speakers of English were used.

Stimuli

A pilot study indicated that nine categories was the largest number that could be tested within the 2-hr time period allotted for the experiment. Thus, one category was eliminated randomly: the category of *clothing*.

Four high-, medium-, and low-rated members of each of the remaining nine categories were used in the basic set of experiments. Constraints on choice of items were that the items not be confusable between the nine categories used in the study (i.e., items were pretested to assure low error rates) and that the items chosen were those which could be represented by readily recognizable simple line drawings. This latter constraint prevented close matching of goodness of example ranks across categories; however, choice of items which could be represented by unambiguous, traditionally representational line drawings was felt to be of greater importance than match in ranks. All of the items used in the nine categories are shown in Table 1.

Different groups of subjects were tested on the items in Sets 1 and 2, which were intended as replications over stimuli using the same categories and design. In addition, a third group of sub-

TABLE 1

SEMANTIC CATEGORY MEMBERS USED

Set	Type	Level of goodness of example: High	Medium	Low
		Furniture		
1	Physically identical	chair	lamp	rug
	Same category	dresser	desk	stove
2	Physically identical	table	stool	fan
	Same category	bed	television	counter
		Fruit		
1	Physically identical	apple	grapefruit	watermelon
	Same category	banana	cherries	boysenberry
2	Physically identical	pear	strawberries	lemon
	Same category	orange	pineapple	nut
		Vehicle		
1	Physically identical	car	airplane	sled
	Same category	bus	bicycle	wheelchair
2	Physically identical	truck	boat	tractor
	Same category	ambulance	trolley car	wagon
		Weapon		
1	Physically identical	pistol	arrow	slingshot
	Same category	sword	tomahawk	whip
2	Physically identical	knife	cannon	fist
	Same category	rifle	club	bow
		Vegetable		
1	Physically identical	peas	celery	mushrooms
	Same category	corn	turnips	potatoes
2	Physically identical	carrots	tomatoes	green onions
	Same category	green beans	artichoke	pumpkin
		Carpenter's tool		
1	Physically identical	hammer	wrench	hatchet
	Same category	drill	bolt	anvil
2	Physically identical	saw	ladder	soldering iron
	Same category	nail	lumber	scissors

TABLE 1—(*Continued*)

Set	Type	Level of goodness of example: High	Medium	Low
		Bird		
1	Physically identical	robin	owl	penguin
	Same category	sparrow	eagle	turkey
2	Physically identical	canary	parrot	peacock
	Same category	blackbird	hawk	chicken
		Sport		
1	Physically identical	football	archery	chess
	Same category	tennis	fishing	horseback riding
2	Physically identical	baseball	fencing	jump rope
	Same category	swimming	ping pong	hunting
		Toy		
1	Physically identical	doll	balloon	mitt
	Same category	ball	skates	tennis racket
2	Physically identical	teddy bear	swing	animals
	Same category	blocks	tricycle	sandbox
		Clothing		
1	Physically identical	pants	stockings	gloves
	Same category	shirt	sandals	purse

jects was tested on a third set of items; the third set was considered necessary because the category membership of some of the items in the first two sets, particularly when presented in the form of words rather than pictures, could be considered ambiguous. Especially problematical was the category *toy,* because virtually any concrete object in any category can occur in a toy version. Set 3 was designed to be free of the possible artifactual ambiguities in the first two sets; this set consisted basically of the items in Set 1 but with those items in the category *toy* replaced by items in the category *clothing* (shown in Table 1) and with the single other Set 1 item whose category membership could be considered ambiguous within the context of the experiment (*hatchet* was considered a *tool* but is also a reasonable *weapon*) replaced by an item which was unambiguous as a tool (*soldering iron*).

Each set of stimuli received by a subject contained three types of items: physically identical pairs (e.g., the same word *chair* or the same picture of a chair simply repeated); pairs which were not physically identical but which belonged to the same superordinate category (e.g., *chair* and *table*), which under the instruction conditions of the present experiment were to be considered *same* by the subject; and pairs of items which belonged to different superordinate categories (e.g., *chair* and *apple*). Items designated physically identical in Table 1 were the items used to form the physically identical pairs. Each item designated same category in Table 1 was combined with the item of that set and rank labeled physically identical to form the same-category pairs.

Different groups of subjects were tested on the items in Sets 1, 2, and 3. These three sets were replications of the design over different items. Each set of stimuli consisted of equal numbers of *same* and *different* items, half the *sames* (1/4 the total pairs) consisted of physically identical items; half the *sames* (1/4 of the total pairs) belonged to the same category but were not the same item; and half the pairs belonged to different categories. A set contained 108 pairs of stimuli: (a) one high-, one medium-, and one low-ranked physically identical pair from each of the nine categories, (b) one high, medium, and low same-category pair from each category, and (c) two high-, medium-, and low-ranked different pairs from each category. High-, medium-, and low-ranked items were always paired with other items of the same rank . Different pairs, even of low rank, were always selected so as to be easily and unambiguously recognized as belonging to different categories.

Pairs of words were typed in IBM Executive letters centered on 12.70 × 20.32 cm white cards. Under viewing conditions in the experiment, an average pair of words subtended a visual angle of 7°. Pictures were simple line drawings taken from various elementary reading instruction materials. They were mounted, centered on 12.70 × 20.32 cm white cards, spaced .635 cm apart, and, on the average, subtended a visual angle of 7°. No pair of words or pictures exceeded a visual angle of 9°. Both members of all pairs could be easily perceived without eye movements.

While words differed in length and frequency and pictures differed in size and complexity, all of which would be expected to affect reaction time to a specific pair, these factors did not need to be carefully controlled in the present priming design. One of the advantages of the priming technique is that it contains a built-in control for factors such as familiarity or visibility which can affect reaction time to a pair as a whole. Each pair occurred both in the unprimed and primed condition with the variable of interest the difference between them; other effects were not of interest unless they affected that difference.

Procedure

Six groups of 10 subjects performed the experiment; different subjects received each set of stimuli, and different subjects received words and pictures.

An interval of 2 sec occurred between the prime and presentation of the stimulus, the interval used by Beller (1971) and used in the basic experiments by Rosch (in press-d). Pairs were presented in a two-field, Harvard-type tachistoscope. Each pair occurred twice, once preceded (primed) by the superordinate semantic category name 2 sec in advance of the pair, once preceded by the word *blank* (to perform the function of a warning signal, part of the function of a prime, see Posner & Boies, 1971). Primed and unprimed trials alternated (this procedure was used by Beller, 1971). The category term or *blank* was spoken by the experimenter who initiated the 2-sec interval as he terminated the word. Subjects were required to repeat the category name or *blank* after the experimenter, a procedure which followed Beller (1971) and Rosch (in press-d). In this, and all subsequent experiments, during the period preceding presentation of the stimulus, the subject was asked to fixate a cross which occurred in the center of a 12.70 × 20.32 cm white field.

Subjects were given the names of the nine categories from which all items were drawn and told that their task was to press one key to indicate *same* if the two items of a pair belonged to the same category and another key to indicate that they belonged to different categories as rapidly as possible without error. Subjects were explicitly told that physically identical items (the same word or picture repeated) were to be considered *same*. Subjects used their dominant hand for the *same* key.

A practice session preceded the beginning of testing. Practice items were drawn from the same nine categories but were not items used in the test sets. Practice sets contained 32 stimuli: 9 physically identical items, 3 from each rank; 9 same category items, 3 from each rank; and 18 different items, 6 from each rank. Each pair was presented once primed and once unprimed for a total of 72 responses. The practice session familiarized subjects with the nature of the stimuli, the judgment required of them, and the mechanics of the apparatus and of making the response. Subjects received feedback on correctness and response time during practice.

For the test trials, each subject received in random order (a different random order for each subject) all pairs, primed and unprimed, from all nine categories, a total of 216 items. A test session lasted 2 hr.

Results and Discussion

Set 1 is the basic set of stimuli used in the experiments throughout this program of research. Set 2 was used in this experiment to provide a replication using different items with the same categories and procedures. Set 3 was used, not as a replication per se, but as an additional test of whether the results achieved with Set 1 were also achieved when ambiguities possibly arising from the inclusion of the category *toy* (and the item *hatchet* in the category *tools*) were eliminated. Thus, the basic analysis of results was performed on Set 1 with its replication Set 2. Results were then compared with the results for Set 3. If results did not differ between Sets 1 and 3, this would constitute evidence that the findings for Set 1 and, thus, the basic findings for all of the following experiments based on Set 1 items were not simply an artifact engendered by the inclusion of one possibly ambiguous category and item in Set 1.

Results for both words and pictures for Sets 1 and 2 combined are shown in Figure 1. The overall error rate was 4%. Although error rates varied slightly by condition in the directions reported by Beller

(1971), none of the tests of significance of the differences between error rates was significant. The most reasonable explanation for the lack of significant error rate differences in the present series of experiments is the lengthy practice session during which incorrect responses were corrected by the experimenter. It is for that reason, probably, that subjects came to emphasize correctness in their responses with—as the speed–accuracy trade-off would predict (Smith, 1968)—corresponding increases in reaction time for the more difficult items. Thus, reaction time appears to be the appropriate variable for analysis; error rates are not discussed further.

The predictions of primary interest were the effect of priming and the interaction of priming with level of goodness of example within the physically identical, same-category, and different conditions, rather than possible differences between those three conditions. Therefore, the results for words and for pictures were analyzed separately for responses to the physically identical, same-category and different stimuli; this is the same procedure of analysis that had been followed by Rosch (in press-d). A four-way mixed-model analysis of variance (ANOVA) was performed for each of the three types of stimulus pairs for words and for pictures. Within-subjects effects were priming, level of goodness of example, and category. Sets 1 and 2 were treated as a replication, a between-subjects effect. Because no effects of replication proved significant, data for the two sets were combined in Figure 1 and will not be discussed separately. Category was treated as a fixed variable since the nine categories used were virtually exhaustive of the population of categories of concrete nouns in common use in English as defined in Experiment 1.[2]

For the physically identical pairs, the ANOVA results confirmed that what appeared to be a large interaction between the effects of priming and level of goodness of example of the pair, was in fact significant for both pictures and words: pictures, $F(2, 36) = 7.95$, $p < .01$; words, $F(2, 36) = 14.31$, $p < .001$. The t tests verified that for both pictures and words, primed responses were significantly faster than unprimed for the good examples: pictures, $t(19) = 3.76$, $p < .01$; words, $t(19) = 11.41$, $p < .001$; and that primed responses were significantly slower than unprimed for the poor examples: pictures, $t(19) = 2.51$, $p < .05$; words, $t(19) = 10.68$, $p < .001$. Primed and unprimed responses did not differ significantly for the intermediate examples for either stimulus type. Thus, as Rosch (in press-d) had found for colors, for physically identical stimuli in same-category instruction conditions, priming

[2] Since Clark (1973), there has been some confusion about the exact conditions under which it is appropriate to treat linguistic and other variables as random rather than as fixed effects. In the present series of experiments, there was reason to argue that either form of analysis was the more appropriate. The categories used were virtually exhaustive of the population to which the author wished to claim the results were applicable; less common categories could not necessarily be expected to yield the reliable goodness of example norms obtained in Experiment 1, and, as noted in the general discussion of this article, more abstract categories or categories at a different level in the class inclusion taxonomies of English were predicted to yield systematically different results, in certain respects, from those of the present experiment. For all these reasons, it appeared mathematically unjustified to treat category as a random effect. On the other hand, the study carries with it the implication that it concerns the processing of superordinate categories other than the specific ones used in this specific research. The following procedures of analysis were therefore used: Category was treated as a fixed effect in the basic analyses of results, and it is these results which are reported in the body of this article. However, in addition, pseudo Fs (Clark, 1973; Winer, 1971) in which category was treated as a random effect were computed for all of those effects which attained significance when category was treated as a fixed effect. F' was computed by the conservative *minimum* method described in Clark; min F' is a statistic always smaller than the Fs from which it is computed. In actual fact, all of the effects of interest on which the theoretical conclusions of the research are based remained significant under min F' computation. In the body of this article, any reported significant effect which was not significant ($p < .05$) by the min F' computation is so noted in parentheses after the report of the F value. (It should be noted that category effects cannot be computed at all when category is treated as a random effect.)

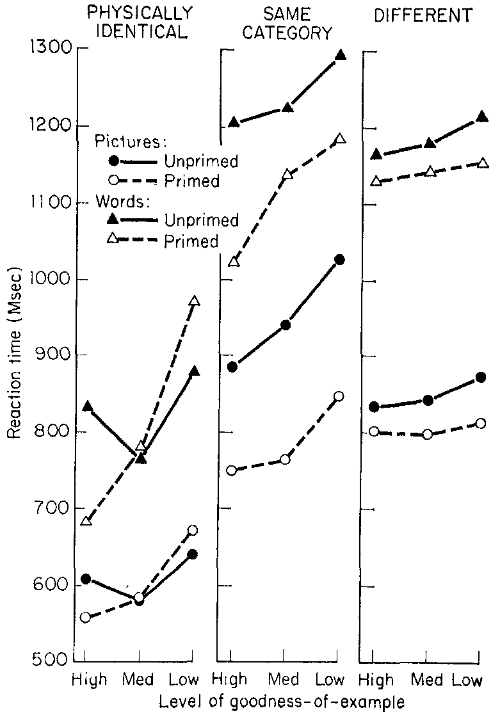

FIGURE 1. Two-sec prime interval, same-category instructions, words and pictures separate.

with the category name facilitated responses to good members of the category and actually hindered responses to poor examples. Intermediate examples appeared truly intermediate in that priming neither facilitated nor hindered them.

Some other effects for the physically identical pairs also attained significance. The main effect for level of goodness of example was significant for both pictures and words: pictures, $F(2, 36) = 9.87$, $p < .001$; words, $F(2, 36) = 19.64$, $p < .001$. As can be seen from Figure 1, the poor example pairs required somewhat longer reactions when unprimed as well as when primed than did the good or intermediate examples. These longer reactions to unprimed poor example pairs than to good examples are not surprising in the light of the fact that, for the stimuli used in this series of experiments, word length, familiarity, visibility, and complexity were not equated between levels of goodness of example, but rather differed slightly (as can be partly observed from Table 1) in favor of the good examples. The intention was to control such factors, not in the stimuli, but in the experimental design, by the occurrence of each pair both in the unprimed and primed condition and by the arrangement of the difference between those two conditions as the variable of primary interest. The differential effect of priming on goodness of example (the interaction between the two variables), not the possible effects of goodness of example itself, was of major interest for the physically identical pairs.

The main effect for category for the physically identical pairs was significant for both pictures and words: pictures, $F(8, 152) = 3.07$, $p < .001$; words, $F(8, 152) = 3.59$, $p < .001$. However, since none of the interactions with category reached significance, the effect is not of interest to the present study. The main effect of priming was not significant for either pictures or words: pictures, $F(1, 19) = 1.57$; words, $F(1, 19) = 2.06$.

In order to test whether the results for physically identical pairs were artifacts of the inclusion of some possibly ambiguous items, the above analyses were also performed on Set 3 alone, and on Sets 1 and 3 together, with set treated as a between-subjects effect. The results for Set 3 followed the identical pattern as those reported above: The Priming $\times$ Level of Goodness of Example interaction was significant for both words and pictures, main effects of goodness of example and of category were significant, and t tests were significant in the same directions as those reported above. Furthermore, the effect of set when Sets 1 and 3 were analyzed together was not significant. Thus, the main results for the experiment did not appear to be a simple artifact of the few possibly ambiguous items in Sets 1 and 2.

The basic finding for the physically identical stimuli of interest to the present hypothesis was, thus, the interaction between effect of priming and level of goodness of example of the stimulus.

The results for the same-category pairs presented a quite different picture. The

Priming × Level of Goodness of Example interaction was not significant either for pictures or words, while the main effect of priming was significant for both types of stimulus: pictures, $F(1, 19) = 21.90$, $p < .001$; words, $F(1, 19) = 20.04$, $p < .001$. Thus, for same-category pairs, priming facilitated responding in general and was as helpful for the intermediate and poor examples of the category as for the good examples.

Other effects which attained significance for the same-category pairs were similar to those significant for the physically identical pairs. The main effect of level of goodness of example was significant for both pictures and words: pictures, $F(2, 36) = 9.24$, $p < .001$; words, $F(2, 36) = 8.90$, $p < .01$. The main effect of category was also significant for both pictures and words: pictures, $F(8, 152) = 4.97$, $p < .001$; words, $F(8, 152) = 5.18$, $p < .001$. None of the other effects for the same-category pairs was significant. Effects for Set 3 were analyzed in a manner identical to that described for the physically identical pairs. As in the case of the physically identical pairs, there were no differences between the effects of Set 1 and Set 3.

For different pairs, the main effect of priming was significant for both types of stimuli: pictures, $F(1, 19) = 8.09$, $p < .05$; words, $F(1, 19) = 7.58$, $p < .05$ (min F' not significant). None of the interactions with priming was significant. The effect of category was significant for words, $F(8, 152) = 3.96$, $p < .01$, but not for pictures, $F(8, 152) = .94$, *ns*. None of the interactions with category was significant. Level of goodness of example was significant for both pictures, $F(2, 36) = 3.51$, $p < .05$ (min F' not significant), and for words, $F(2, 26) = 3.82$, $p < .05$ (min F' not significant). As in the case of physically identical and same-category pairs, effects of Set 3 did not differ from those of Set 1.

Of themselves, the results of Experiment 2 establish two points. First, they show that priming with superordinate semantic categories can have significant effects in a same–different matching task; that is, the results establish the possibility of using this technique to investigate these types of stimulus materials. Second, the results suggest that the representation of superordinate semantic categories is something more than a list of criterial attributes which, by definition, must be common to all members of the category and which should thus be affected equally by priming for all members of the category. The actual findings were that for one type of stimulus, physically identical pairs, priming speeded responses to good examples of the category and slowed responses to poor examples.

However, two additional tests were needed before these results could be further interpreted. First, the present experiments were claimed to be investigations of the *internal* structure of semantic categories; one of the basic assertions is that all of the instances of a category are indeed members of the category, differing only in the extent to which they represent subjects' ideas or images of the meaning of the category name. However, it is possible to argue that the poor examples of categories used in Experiment 2 were, for subjects, actually members of different categories entirely. Posner and Snyder (1975) have shown that when, in a priming task, subjects are "fooled" on 20% of the primed trials (i.e., are shown a pair which should be designated *same* according to the instructions, but which is misnamed by the prime), priming facilitates response time on the trials for which the prime is correct and inhibits response time for the trials on which the prime is incorrect. Results of the present experiments would be far from interesting were they obtained simply because the poor example items were actually members of other categories and thus incorrectly primed by the category name used (as is suggested in the Loftus commentary). It appeared necessary, therefore, to compare the results obtained by use of the present experimental paradigm with those obtained when actual incorrect primes were administered. That comparison is carried out in Experiment 3.

The second test which is needed before the results of Experiment 2 can be further interpreted is inherent in the logic of the priming technique, as discussed in the introduction to this article and as demonstrated by the pattern of results in the experiments in Rosch (in press-d). Interpretation of the results of priming with a 2-sec delay (either of the predicted results for the physically identical pairs or the anomalous results for the same-category pairs) can only be made when compared to results of a prime administered simultaneously with the stimulus. Experiment 4 was designed to provide the necessary comparison.

Experiment 3

Keele (1973) and Posner and Snyder (1975, in press) make a distinction between the effects of conscious attention—which directs scarce processing capacity to an attended item, thus producing facilitation of performance for that item and a decrement in performance for unattended items—and the effects of unconscious activation—which can produce facilitation for one item without a corresponding decrement for other items. In one set of experiments designed to support the distinction, a priming technique was used in which the proportion of trials in which the prime provided the subject with correct information was systematically varied. When the probability that the prime was informative was high (e.g., 80% of the primes were correct; 20% incorrect), subjects showed a gain in both speed and accuracy of responses to correctly primed items and a loss in speed and accuracy of responses to incorrectly primed items. On the other hand, when the probabilities were reversed (20% of the primes were correct, 80% incorrect), there were small but significant facilitation effects on the correctly primed trials but no corresponding decrements on the incorrectly primed trials. These differences were assumed to support the differential effects of conscious and unconscious activation.

The empirical pattern of results in the condition in which the majority of trials (80%) were correctly primed and a minority (20%) incorrectly primed was similar to that obtained for the physically identical items in Experiment 2 of the present research. Were the results of Experiment 2 obtained simply because the poor example items (33% of the items) were actually members of other categories and, thus, incorrectly primed by the category name used? The purpose of Experiment 3 was to test such a possibility by use of an experimental paradigm similar to that of Experiment 2 but in which, on 33% of the primed trials, a category name was given which was known to be an incorrect designation of the items. That is, in Experiment 3, the basic design of Experiment 2 was repeated with the exception that the poor example items were replaced by items from a category which was unequivocally not named by the prime. If Experiment 3 is a true analogue of Experiment 2—if it embodies the elements of design which led to the results of Experiment 2—the pattern of results obtained in Experiment 3 should be very similar to those obtained in Experiment 2.

Method

Subjects

Subjects were 20 native English-speaking students in introductory psychology classes who had not participated in any of the other experiments. They received course credit for their participation.

Stimuli and Procedure

Sets 1 and 3 of Experiment 2 were used as stimuli; the single change in stimulus materials was that all of the poor example pairs were replaced by good example pairs taken from categories other than the one which was primed. (The unprimed pairs corresponding to the changed primed pairs were, of course, also changed.) Ten subjects received Set 1, 10 subjects Set 3. Procedures of administration and practice were identical to those of Experiment 2.

Results and Discussion

Results for correctly and incorrectly primed good example items, for the two sets combined, are shown in Figure 2. The results were analyzed in the same manner as described for Experiment 2; the effect of set was treated as a between-subjects variable. Incorrectly primed items filled the same position in the design (one level of the goodness of example variable) that the poor example items had filled in Experiment 2. The results of the ANOVAs were simple: For none of the types of pairs (physically identical, same-category, or different) did any of the effects (priming, goodness of example, or the Priming × Goodness of Example interaction) achieve significance. The only significant effects of interest were those of two t tests. These tests indicated a significant facilitation effect (i.e., decrease in reaction time) for correctly primed good example pairs of physically identical pictures, $t(19) = 2.66$, $p < .05$, and significant facilitation of reaction time for correctly primed good example pairs of same-category words, $t(19) = 2.28$, $p < .05$. There were no significant effects for error rates, perhaps, as in Experiment 2, because of the emphasis on correctness apparently conveyed by the feedback in the practice session.

The results of Experiment 3 were in marked contrast to those of Experiment 2. None of the effects of interest in Experiment 2 (the Priming × Level of Goodness of Example interaction for physically identical pairs and the general facilitation by priming for both good and poor example same-category pairs) was obtained in Experiment 3. In particular, the decrement (i.e., increase) in response time for primed physically identical poor example pairs, the effect which had appeared possible to attribute to the fact that those items were not really members of the primed category, was not obtained in Experiment 3 when those items were unequivocally not members of the primed category. Thus, the results of Experiment 2, particularly the Priming × Goodness of Example interaction for physically identical pairs, do not appear to be artifacts of the possible fact that poor example pairs actually belonged to categories other than the ones named in the prime.

Why should priming with an incorrect category name not have suppressed reaction time for the physically identical pairs in Experiment 3? Such a finding appears to fit the Keele (1973) and Posner and Synder (1975, in press) models of attention. The results of Experiment 3 (for both physically identical and same-category items) are similar to those obtained by Posner and Snyder (1975) in the condition in which the majority of primed trials (80%) were incorrectly primed. Posner and Snyder

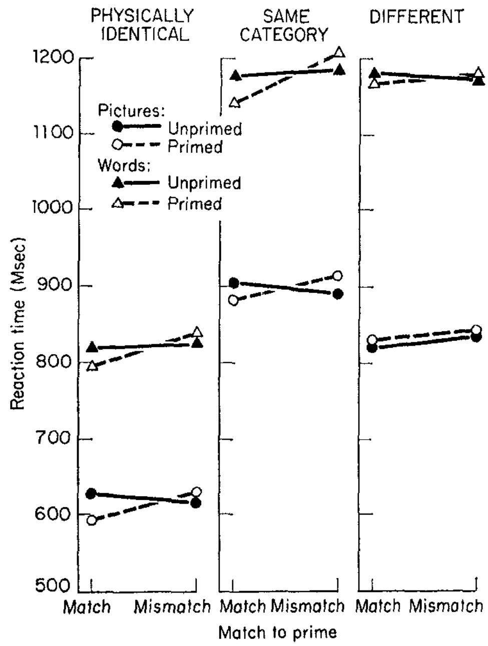

FIGURE 2. One third of items incorrectly primed, 2-sec prime interval.

attribute the small facilitation and lack of decrement obtained in this condition to the fact that subjects came not to attend consciously to the prime. Subjects in the present experiment commented during practice on the disruptive effects of being "fooled" by the prime and reported ignoring the priming when performing the experiment. The difference between the present experiment and Posner and Snyder (1975) is in the low percentage of incorrectly primed trials which appeared able to produce withdrawal of conscious attention from the prime in the present experiment. The design of the present experiment differed from that of Posner and Snyder (1975) both in that the matching task was more complex than their tasks and in that the prime and stimuli were presented in different modalities (the prime was auditory, the stimuli visual), whereas in Posner and Snyder's tasks both prime and stimuli were visually presented. Either or both factors may have contributed to subjects' inattention to the prime under the present experimental conditions. (Other examples of lack of processing of the prime by subjects in the present research design occurred in Experiments 5 and 6).

While Experiment 3 has indicated that the effects of the internal structure of categories on priming cannot be dismissed as an artifact of the fact that poor examples of categories are actually members of other categories, it is undeniable that the poor examples of the categories used in the present research were "closer" to other categories than were the good examples. However, this was not due to an artifactual choice of particular items; rather, it is a necessary aspect of the structure of real world categories. That is, categories appear to form in the real world in a manner which renders them maximally discriminable from each other, and, thus, the best examples of categories are those items both with the most attributes in common with other members of the category in question and with the least attributes in common with, or least possibility of membership in, other categories; such facts have been demonstrated for both natural and artificial categories (Rosch & Mervis, in press; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, in press; Rosch, Simpson, & Miller, Note 1). These facts are some of the structural bases which may lie behind the norms of Experiment 1; the purpose of the present research, however, was not to investigate the formation of categories but to examine the nature (i.e., the structure and content) of the cognitive representation of the category (as it is generated from hearing the category name). What appears to be the case is that the natural structure of categories (which is quite different from a list of attributes necessary and sufficient for category membership) is represented in the cognitive representation of the category.

Experiment 3 has clarified one aspect of the meaning of the results of Experiment 2; namely, it has shown that the results of Experiment 2 were not an artifact of the use of poor example items which were actually members of categories not named by the prime. However, there remains a second aspect of Experiment 2 for which comparison data must be obtained before the results of Experiment 2 can be interpreted. According to the logic of priming outlined in the introduction, interpretation of the results of priming with a 2-sec delay (the condition of Experiment 2) can only be made when compared to results obtained when the prime is administered simultaneously with the stimulus. Experiment 4 was designed to provide the necessary comparison.

Experiment 4

In Experiment 2, priming selectively facilitated and impeded responses to good and poor examples of categories for physically identical pairs, and it had a constant facilitatory effect on same-category and different pairs, regardless of level of goodness of example. Any of these outcomes, however, could as well have been the result of effects on decision processes after the stimuli were presented as the result of generation of a representation of the category prior to presentation of the stimuli. The present experiment was designed to test the locus of the facilitation effect by simultaneous presentation of the prime and the stimulus pair. Priming effects which are the result of generation of a representation prior to viewing the pair should disappear if the prime and the visual stimulus are presented simultaneously. On the other hand, priming effects which are at least partly the result of decision time after the pair is present should still occur when the prime and visual stimulus are presented simultaneously.

Method

Subjects

Subjects were 20 native English-speaking students in introductory psychology classes who had not participated in the previous experiments. They received course credit for their participation.

Stimuli

Because in the previous experiments, effects of Set 1 had been shown not to differ from those of Set 2 (or Set 3), it appeared justifiable to use only the Set 1 stimuli in the present experiment.

Procedure

With two exceptions, procedures were identical to those in Experiment 2. In the present experiment, instead of a 2-sec interval between the prime or *blank* and presentation of the stimulus pair, the pair of stimuli were presented to the subject simultaneously with the experimenter's utterance of the category name or *blank*. In order to assure that utterance of the prime or *blank* and onset of the stimulus were, in fact, simultaneous, the experimenter first engaged in two practice sessions, the second of which was tape-recorded. The recording was checked to ascertain that the click denoting the relay which initiated stimulus onset invariably occurred during the interval of sound denoting the experimenter's utterance. This was, in fact, found to be the case. The 20 test sessions were also tape-recorded and the first and last sessions were similarly checked. Of the 432 trials represented by the two sessions, there was difficulty on only one trial in which the beginning of the experimenter's word was obscured by a cough.

The second change in procedure was elimination of the requirement that the subject repeat the prime or *blank* after the experimenter, a change made necessary by the fact that when the prime and stimuli were presented simultaneously, a subject's repetition of the word interfered with his ability to make a response. In Rosch (in press-d) the patterns of results with and without subject repetition were found to be identical. In order to assure that the omission of subject repetition did not change the effects found for semantic categories in Experiment 2, five subjects were tested with pictures and five with words using Set 1 stimuli and Experiment 2 procedures modified by the omission of the repetition requirement. As in Rosch (in press-d) the same pattern of results was obtained from these subjects as from the original groups in Experiment 2. This testing served both as a replication of the Experiment 2 findings and as a pilot study making possible the procedures of Experiment 3.

Results and Discussion

Results for reaction times are shown in Figure 3. Overall error rate was 6%. As in previous experiments, there were no significant changes of error rate in any of the conditions. Results were analyzed as in Experiment 2. For the physically identical condition, the Priming × Level of Goodness of Example interaction was not significant for either pictures or words. Thus, as for colors (Rosch, in press-d), presentation of the prime simultaneously with the physically identical stimuli eliminated both the faciliatory and inhibitory effects of priming. The only remaining significant effects under this condition were the main effects of level of goodness of example: pictures, $F(2, 38) = 6.03$, $p < .01$; words, $F(2, 38) = 5.85$, $p < .01$; and the main effect of category: pictures, $F(8, 152) = 2.60$, $p < .05$ (min F' not significant); words, $F(8, 152) = 2.71$, $p < .01$ (min F' not significant).

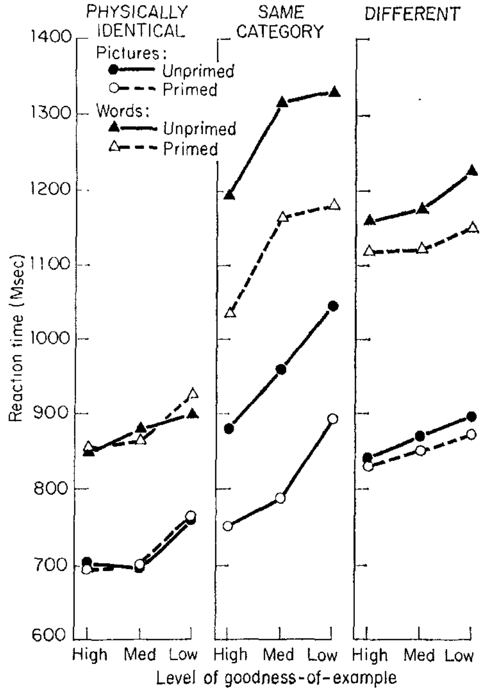

FIGURE 3. Simultaneous prime, same-category instructions, words and pictures separate.

According to the logic of the present research, if a prime facilitates a response prior to but not simultaneously with a stimulus, the representation generated by the prime in advance of the stimulus can be inferred to affect the response. The physically identical stimulus condition thus is clearly a condition which allows us to investigate the primary topic under study: the nature of the representation generated when we hear a category name and understand its meaning. The import of the findings for physically identical stimuli will be discussed further below.

For the same-category condition, the results were quite different. The main effect of priming was significant for both pictures and words: pictures, $F(1, 19) = 23.80$, $p < .001$; words, $F(1, 19) = 22.29$, $p < .001$. The Priming × Level of Goodness of Example interaction was not significant. As in the physically identical condition, main effects of level of goodness of example were significant: pictures, $F(2, 38) = 6.47$, $p <$

.01; words, $F(2, 28) = 7.10$, $p < .01$. And category was significant: pictures, $F(8, 152) = 4.01$, $p < .001$; words, $F(8, 152) = 4.77$, $p < .001$. No interactions were significant.

For different responses, effects were very similar to those found for the same-category responses. For both pictures and words, there was a significant main effect of priming: pictures, $F(1, 19) = 4.52$, $p < .05$ (min F' not significant); words, $F(1, 19) = 8.26$, $p < .01$. There was no Priming × Level of Goodness of Example interaction. As in previous conditions, the main effect of level of goodness of example was significant; pictures, $F(2, 38) = 5.20$, $p < .01$; words, $F(2, 38) = 4.13$, $p < .05$ (min F' not significant). And the main effect of category was significant: pictures, $F(8, 152) = 2.78$, $p < .01$ (min F' not significant); words, $F(8, 152) = 4.17$, $p < .001$. Interactions were not significant.

The patterns of results for the same-category and different stimuli were quite different and appear to warrant a quite different interpretation from the results for physically identical stimuli. In these cases, priming affected reaction time both when presented prior to and simultaneously with a stimulus. The following discussion is designed to demonstrate that in such a case, due to the possible interaction between stages of processing (which rendered Donders', 1969, additive model of reaction time inoperable; see Sternberg, 1969), it is impossible to verify any specific model of the processing of items in the task. Let us take as an example the case of the same-category items.

There are three major ways in which the results for same-category items differ from those for physically identical items: (a) The overall reaction time for same-category items, both unprimed and primed, was greater than for the physically identical items. (b) There was uniform facilitation of response time both for good and poor examples of the category for the same-category items; whereas for physically identical items, there was facilitation only for primed good examples and a decrement in response time for the primed poor examples. (c) For same-category items, the effect of advance priming was not eliminated when the prime was presented simultaneously with the items; whereas in that condition it was eliminated for physically identical items.

The difference in overall reaction time to the two types of items is relatively trivial. To respond to same-category items, the subject must not only go through the encoding process required for all items but must, in addition, perform judgments not required for physically identical items; that is, the subject must, in some form, determine category membership for the items and judge whether or not the category of both items is the same. Same-category items have consistently been found to require longer reaction times than physically identical items under a wide variety of conditions (Posner & Mitchell, 1967). This effect is not of interest per se for the present study.

It is the second difference which is of major interest: Why should advance priming facilitate response time equally for good and poor same-category pairs when it does not have such an effect on physically identical pairs? The third difference, the occurrence of priming effects for same-category items under conditions of simultaneous priming, is of interest primarily for its ability to cast light on the second difference.

If it is assumed that there are two basic, separate stages in the processing of same-category items, an encoding stage in which the subject perceives the stimulus item and a decision stage in which the subject makes decisions about the category membership of the items, then there are two basic types of stage models which can characterize the effect of the prime on same-category items. In a two-stage model, the observable effect of priming is attributed both to the effect of the prime on the encoding stage and to its effect on subsequent decision processes. In a one-stage model, the observable effect of the prime is attributed only to the decision stage.

Consider the general form of a two-stage model. When the prime is presented prior to the stimulus pair, it should affect encoding of the pair in an identical manner to its effect on physically identical pairs, speeding responses to good examples and slowing responses to poor examples (as shown in Figure 1). That is, since the subject does not know in advance what type of pair he will see, priming should affect encoding of all pairs equally. For same-category items, the subject perceives (or judges) that the members of the pair are not physically identical (which may or may not be a separate step from perceiving the items themselves), and must now proceed to consider category membership. If the trial is not primed, the subject must retrieve the superordinate category names from memory. (He may either retrieve the superordinates for each member separately, comparing them to determine whether they are the same, or, as suggested by Smith, Shoben, & Rips, 1974, he may retrieve the superordinate name for the first member of the pair and then confirm or disconfirm that the second member belongs to that same category; which process is used is irrelevant to the present argument). Since poor members of categories are slightly more difficult to perceive than good members (see Experiment 2) and since superordinates for poor members are probably more difficult to retrieve from memory than for good members (indirect evidence in Loftus & Scheff, 1971, and Rosch & Mervis, in press), longer response times should be expected for poor members of unprimed same-category pairs than for good members. Such an effect of goodness of example on unprimed pairs was, in fact, obtained (see Figures 1 and 3).

The two-stage model must now explain how the Priming × Level of Goodness of Example interaction obtained in the encoding stage is reversed in the decision stage such that the final effect is an equal facilitation of primed responses for good and poor category members. Priming provides a superordinate category name, thereby eliminating the need for the memory retrieval of a superordinate (or superordinates) and changing the retrieval task into a verification task of the type in which subjects answer *true* or *false* to statements of the form "A (member) is a (category)." Previous work has already established that category membership of good members of categories is verified faster than that of poor members (Rips, et al, 1973; Rosch, 1973); that fact would of itself tend to increase, rather than eliminate, the Priming × Level of Goodness of Example interaction. In order to eliminate the interaction, it must be assumed that: (a) retrieval of superordinates of poor members of categories is a very much more difficult task than retrieval of superordinates of good members, (b) because retrieval of poor category members is so difficult, the gain in reaction time obtained by turning the retrieval task into a verification task is greater for poor members than for good ones, and (c) in fact, this relatively greater gain in time for poor members obtained in the change from retrieval to verification is great enough to offset both the decrement in response time for poor members created by priming in the encoding stage and the relatively slower verification times themselves for poor than for good members. That retrieval of poor members is indeed considerably more difficult than for good members can be argued from the finding in Rosch and Mervis (in press) that, due to the structural nature of categories, poor members have more attributes in common with and belong to more superordinate categories than good members. For the sake of argument, the offset of this retrieval difficulty by priming of poor members may be assumed to be just great enough to counteract the interactions expected from encoding and verification times. Only such a quantitative equalization could produce the uniform facilitation of good and poor members of same-category pairs shown in Figures 1 and 3. Such a two-stage model is quite similar to that offered by Loftus (in her commentary on this article) with the exception that the present account makes explicit the processes which must be assumed if the encoding stage Priming × Level of Goodness of Example interaction is to be offset in the decision stage.

The problem with such a model is that it does not fit the data; that is, it does not fit Experiments 2 and 4 considered together. If the reaction times for same-category pairs in Experiment 2 are due to the effect of the prime on encoding plus the effect of the prime on decision processes, there should be systematic differences between the case in which the prime is presented 2 sec in advance of the stimulus and thus affects encoding (Experiment 2), and the case in which prime and stimulus are presented simultaneously and the prime does not appear to have sufficient time to affect encoding (Experiment 4). If there is no Priming × Level of Goodness of Example interaction during encoding, primed good examples would expectably be relatively slower and primed poor examples would be relatively faster than in the case where there is an encoding stage interaction to counterbalance. Thus, for the same-category pairs, responses to primed good examples would expectably be slower in Experiment 4 than in Experiment 2 and responses to primed poor examples would be faster in Experiment 4 than in Experiment 2.

To test possible differences for same-category items in Experiments 2 and 4, a mixed-model, four-way ANOVA (Priming Interval × Priming × Level of Goodness of Example × Category) was performed separately for words and for pictures for the same-category responses of Experiments 2 and 4. Priming interval (2 sec vs. simultaneous), the variable of greatest interest, was a between-subjects variable; the other variables were within-subjects. The results show that there were no effects, either main effects or interactions, of priming interval for either pictures or words. As an additional check on the existence of possible differences between the effects of priming in the 2-sec and simultaneous conditions for both pictures and words, *t* tests were performed on the differences between primed and unprimed responses for the 2-sec and simultaneous conditions separately for each level of goodness of example. None of the six *t* tests was significant. Thus, the two-stage processing model fails to fit the facts of lack of difference between same-category pairs under 2-sec delay and simultaneous priming conditions.

The data from Experiments 2 and 4 lead to consideration of a one-stage model of the processing of same-category pairs, a model in which priming is considered to affect only the decision stage for such items. In a one-stage model, the encoding stage need not be considered, and, thus, a theory which generates the reversal (counterbalancing) of the encoding stage Priming × Level of Example interaction is not needed.

How might a one-stage model work? For unprimed trials, poor examples would be expected to require longer response times than good examples for the same reasons enumerated in describing the two-stage model. To explain the effect of priming, a one-stage model need only explain why primed responses are generally faster than unprimed and why primed responses to good examples are faster than primed responses to poor examples. Primed responses would be generally faster than unprimed if priming can be assumed to turn a memory search plus verification task into a pure verification task, and if verification alone is faster than search plus verification. As explained earlier, both are reasonable assumptions. Primed responses to good examples would tend to be faster than primed responses to poor examples both as a result of the fact that, in the present experiment, unprimed good examples have faster response times than unprimed poor examples and as a result of the known fact that verification of good examples of categories is faster than verification of poor examples (Rips et al., 1973; Rosch, 1973). By these few assumptions, the uniformly beneficial effect of priming for same-category pairs is accounted for. The one-stage model has the advantage that it fits the data for Experiments 2 and 4 considered together. It also has the advantage that it is simpler than the two-stage model and need not make "strained" quantitative assumptions about the relatively greater advantages of verification over search for poor than for good category members.

The one-stage model has the disadvantage that it is a thoroughly unreasonable account of the processing of same-category pairs under conditions in which the prime is presented 2 sec in advance of the stimulus pair. Given that under these conditions priming affects the encoding of physically identical pairs, and given that subjects do not know in advance whether they will see a physically identical or a same-category pair, it is unreasonable to assume that priming does not also affect the encoding of same-category items. Thus, neither model appears to offer a viable account which fits all of the data.

A very similar logic can be applied to the different pairs. A two-stage model predicts differences between Experiments 2 and 4 which failed to occur. A single-stage model is an unreasonable account of the results of Experiment 2.

The only reasonable conclusion appears to be that we cannot have an additive model of encoding and decision time stages for a priming task of this nature. Encoding and decision stages appear to interact in those cases in which decisions about category membership are required (same-category and different items). Given present conceptions of cognitive processes and the lack of quantification of the stages hypothesized for those processes, we cannot make inferences about the occurrence or nonoccurrence of processes when interactions such as these appear to be present. Thus, the conclusion from the results of Experiments 2 and 4 taken together must be that it is only in the case of physically identical items that we can make inferences about the basic question of the study: the nature of the cognitive representation generated when we hear a category name and understand its meaning.

What have the results of Experiments 2 and 4 shown about the nature of that representation? An assumption of the priming method is that a prime can only facilitate a response if it contains within it some of the information needed to make that response. Because of the selective effects of internal structure on priming, the facilitation of responses for good and inhibition of responses for poor category members, it is clear that the representation contains more of the information needed to respond to good than to poor category members. But it is not clear in what form that information is given. Because advance but not simultaneous priming affected physically identical pairs, it can be inferred that the representation generated by the superordinate category name contained some of the information used by subjects in the actual perception of the stimulus. But that does not tell us much about the form of the information. The information must be abstract enough to have similar facilitatory and depressive effects on very different items belonging to similar levels of goodness of example of a category and similar effects on stimuli presented in the very different visual forms of words and pictures; yet the information must be concrete enough to affect the actual perception of specific items. The following two experiments were designed to investigate the issue of the concreteness of the representation and its effect on different levels of encoding.

Experiment 5

How concrete, how specifically visual, a mental representation can be produced from hearing the superordinate semantic category terms used in the present series of studies? Can subjects actually generate visual configurations which are aspects of possible pictures and words?

Experiments 2 and 3 used instructions which defined *same* as belonging to the same category. A series of experiments (summarized by Posner, 1969; Beller & Schaeffer, Note 2) have demonstrated that stimuli in a matching task are processed at a far more concrete and physical level when instructions define *same* as physical identity than when instructions define *same* as same category. Rosch (in press-d) found that the representation generated by color category names produced the same selective effects on physically identical pairs under both types of instruction, arguing that color terms can generate a quite concrete mental representation. If the representations generated by superordinate category names contain some concrete elements (e.g., representations of features such as possible lines and angles of pictures or letters in words), differential effects of priming for physically identical pairs should be found under physical identity instruction conditions which are similar to those found for

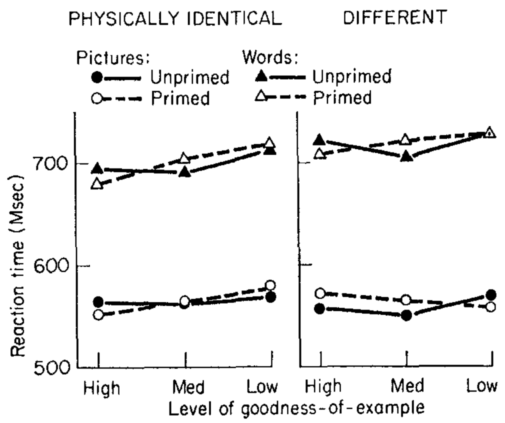

FIGURE 4. Physical identity instructions, 2-sec prime interval, words and pictures separate.

physically identical pairs under same-category instruction conditions. The present experiment used physical identity instructions.

Method

Subjects

Subjects were 40 students in introductory psychology classes who had not participated in any of the previous experiments. All were native speakers of English. They received course credit for participation.

Stimuli

Stimulus pairs were the same as those used in the physically identical and different pairs of Experiment 2. In order to have the same number of pairs as used in the previous experiments and in order to keep the number of same and different responses equal, it was necessary to double the number of physically identical pairs while removing the same-category pairs. Since Sets 1 and 2 had appeared to be completely equivalent (there were no effects of replication in Experiment 2), the physically identical pairs from Sets 1 and 2 (shown in Table 1) were both used in the present experiment. Different pairs consisted of half the Set 1 and half the Set 2 different stimuli.

Procedure

Procedures were the same as for Experiment 2 with the exception that instructions were to press the *same* key only when the members of a pair were physically identical and to press the *different* key for all other pairs. The practice set was adjusted to reflect the new conditions. Twenty subjects received picture stimuli, 20 received words.

Results and Discussion

Results for both words and pictures are shown in Figure 4. Error rate was 1.5%. As in previous experiments, there were no significant differences in any of the analyses of error rate. A within-subjects three-way ANOVA (Priming × Level of Goodness of Example × Category) was performed separately for same and different responses. The results were strikingly simple: There were no main effects of priming and no Priming × Level of Goodness of Example interactions in either the same or different conditions. The few significant effects that did occur were not relevant to the hypothesis: a significant main effect for level of goodness of example for same responses to the word stimuli, $F(2, 38) = 4.61$, $p < .05$ (min F' not significant), and significant main effects for category for the words stimuli, same, $F(8, 152) = 3.58$, $p < .001$; different, $F(8, 152) = 2.71$, $p < .01$ (min F' not significant).

The purpose of Experiment 5 was to determine whether the representations generated by superordinate category names contained visual elements of sufficient concreteness to facilitate responses under physical identity instructions. Since there was no effect of priming at all under physical identity instructions, the answer appeared to be that they do not. Such results, however, contain a paradoxical element. The results of Experiments 2 and 4 indicated that representations generated by superordinate category names in advance of presentation of the stimulus contained some of the information used by subjects in the actual perception of the stimulus. Yet Experiment 5 has shown that what we normally consider the elements of perception —physical visual representations such as lines, curves, and angles—are not part of the information provided by the superordinate category name. These apparently contradictory results suggest that less concrete aspects of the representation of the category name, aspects of the meaning of the name itself, constitute the information which was used by subjects to selectively facilitate perception of the stimuli in Experiment 2.

It is of great interest to demonstrate that perception of the meaning (identity) of a stimulus is an actual perceptual process, as defined by the operations and logic of the present series of studies. The demonstration depends upon two steps: (a) Under physical identity instructions in which subjects do not process the meaning but only the physical configuration of the stimulus, priming with the superordinate category name has no effect on perceptual encoding of physically identical pairs. (b) Under same-category instructions when subjects must prepare to process all pairs as meaningful stimuli, representations generated by superordinate category names in advance of the stimulus do affect the perceptual encoding of physically identical stimuli. Hence, it must be an aspect of the meaning itself which affects perceptions in the same-category instruction condition.

However, this argument makes one assumption, which, without proof from some source other than the present experiment, is circular. It is assumed that subjects do not encode the identity or meaning of the stimuli under physical identity instructions because the prime, which affected physically identical pairs under same-category instructions, did not affect such pairs under physical identity instructions. The purpose of Experiment 5 was to provide converging evidence from a quite different experimental paradigm that the stimuli used in the present series of experiments are encoded as meaningful items under same-category but not physical identity instructions.

Experiment 6

Research on incidental learning (Hyde & Jenkins, 1973; Till & Jenkins, 1973; Walsh & Jenkins, 1973) and on levels of processing in memory (Craik & Lockhart, 1972) has shown that the task which subjects are told to perform on a list of items affects their later ability to recall the items. Tasks which require a "low level" visual processing, such as estimation of the number of occurrences of the letter *e*, result in considerably lower levels of recall of words than tasks which require processing of the meaning of the words, such as judging each word for its pleasantness. In addition, there is evidence that cues that are psychologically present for a subject at the time when he is encoding a word are more effective in enhancing later recall than cues not present at the time when subjects are encoding the words (Tulving & Thomson, 1973).

The results of Experiment 4 suggested that it was the cognitive representation of the meaning of category names which affected the perceptual encoding of physically identical pairs in Experiment 2. To substantiate this argument it is necessary to show that under physical identity instructions, subjects do not encode the stimuli as identified meaningful items. Using the logic of incidental learning and of cued recall, it can be predicted that if, under the physical identity instructions of Experiment 5, subjects processed items at a purely visual level without identifying them, recall for items should be very poor. Furthermore, if items were not processed as meaningful units, even though subjects were continually hearing and repeating the category name, those names should be ineffective cues for recall. By the same logic, it can be predicted that if, under the same-category instructions of Experiment 2, subjects did process the stimuli as identified, meaningful items, recall of items under those instruction conditions should be superior to recall of items under physical identity instructions. In addition, under same-category instruction conditions, cuing with the category name should produce an improvement in recall.

Method

Subjects

Eighty subjects from introductory psychology classes who had not been subjects in any of the previous experiments participated. They received course credit for their work.

Stimuli

Stimuli used in the physical identity instruction condition were the same as those used in Experiment 5; stimuli used in the category identity instruction condition were the same as those used in Set 1 of Experiment 2. In each instruction condition, there were 54 actual items which could

TABLE 2

Number of Items Recalled in Free Recall

Instruction condition	Number of items recalled			
	Words		Pictures	
	Uncued	Cued	Uncued	Cued
Physical identity instructions	3	2	6	6
Category same instructions	10	14	16	21

be recalled. There was a small difference in the distribution of those 54 items as can be seen from the methods sections of Experiments 2 and 5; however, there is no reason to believe that either of the distributions should favor or depress recall. In addition, the cued group had exactly the same distribution of items as the uncued group for each of the instruction conditions.

Procedures

There were four experimental conditions: physical identity instructions without cued recall, physical identity instructions with cued recall, same-category instructions with cued recall, and same-category instructions without cued recall. Each of the four conditions was administered to one group of subjects for the picture stimuli and to another group of subjects for the word stimuli. Ten subjects served in each of the resultant eight conditions.

Priming procedures for the same-category conditions were identical to those of Experiment 2 and for the physical identity condition identical to those of Experiment 5. At the conclusion of the priming session, the subject was given a sheet of paper and asked to write down all of the items which he had seen. Ten min were allotted for this task; subjects who claimed to have finished before this time interval ended (and the majority of subjects did) were required to remain and attempt to recall additional items. In the uncued condition, the subject was provided with no information at the time of recall. In the cued condition, the subject was provided with a list of the nine category names which he could refer to at will throughout the 10-min period of recall. In fact, when asked to describe how they performed the task, most subjects in the uncued condition reported making their own list of category names as a memory aid; however, they also reported being unable to recall all nine categories. Thus, the effect of cuing was to supply not nine category names but the one to four categories which uncued subjects appeared unable to provide themselves.

Results and Discussion

The purpose of Experiment 6 was to show, by means of converging operations, that in the same-different matching paradigm used in the present series of experiments, stimuli are encoded as meaningful items under same-category instructions but not under physical identity instructions. Implications for the memory task of Experiment 6 were that items should be recalled better under same-category than under physical identity instructions, and cuing with the category name should be a greater aid to recall under same-category than under physical identity instructions.

The mean number of words recalled in the eight conditions are shown in Table 2. A three-way ANOVA (Instruction Condition × Cuing × Words vs. Pictures) was performed. Of primary interest was the predicted effect of instruction condition and the Cuing × Instruction condition interaction. The main effect for instruction condition was highly significant, $F(1, 79) = 20.92$, $p < .001$. As Table 2 shows, memory for items under physical identity instructions was minimal. The main effect for cuing was significant, $F(1, 79) = 10.75$, $p < .01$, and the Cuing × Instruction condition interaction was significant: $F(1, 79) = 13.89$, $p < .001$. Cuing significantly improved recall only for the same-category instruction condition. Pictures were recalled better than words, $F(1, 79) = 7.03$, $p < .05$, an effect which did not interact either with instruction condition or cuing.

Thus, the main hypotheses of the experiment were confirmed. Under physical identity instructions, stimuli appear to be processed at a level sufficiently lacking in meaning that such items were difficult to recall. Furthermore, in the physical identity instruction condition, despite hearing the category name in conjunction with each item twice (once in the same and once in the different primed conditions), cuing with the category name produced no improvement in recall. Thus, it is possible to conclude that stimuli in this condition are processed as concrete visual configurations rather than as identified meaningful objects.

Experiment 6 provided the needed convergent evidence that it was not the representation of visual configurations but rather an aspect of meaning contained in the representation generated by category name primes which affected the perceptual encoding of physically identical pairs in Experiment 2. How is that meaning represented? Experiment 7 addressed this question further.

Experiment 7

One of the more surprising aspects of the findings of Experiments 2 and 3 is that, while the selective effects of the representation generated by the prime appear to be present only in the condition of physically identical stimuli, they show identical patterns of results for words and for pictures. While it might be thought that good but not poor examples of categories that have been processed as meaningful items might have some very general visual features in common (such as legs and surfaces for furniture) which the category name could arouse and which could act selectively on perception of items, what possible visual features can words (names) for the good examples of categories arouse? And if the representation were simply a word list of the names of category members ordered according to goodness of example, how can we explain the effects of the prime on pictures? We come again to the central question: What can be the nature of the representation generated by the category name such that it affects perception of physically identical pairs in the ways which the previous experiments have shown it does? The only possibility appears to be that the category name prime arouses an abstract ordered set of inclusion probabilities of the meanings of items that might be included.

The present experiment was designed to explore two possible forms in which the ordered set of inclusion probabilities for the category might be represented. On the one hand, it could be represented by a general meaning common to words and pictures. On the other hand, the list of possibilities might be in the form of a set of very general pictorially possible items in the picture condition and very general word possibilities in the word condition. Single versus dual coding hypotheses are an issue of present debate in psycholinguistics (Clark, Carpenter, & Just, 1973; Paivio, 1971), and the methods of the present study make possible an investigation of a related, though not identical, question with regard to the nature of the code generated by superordinate category names.

If the set of inclusion probabilities aroused by the category name is specific to a word or picture modality, that is, if a quite different representation of possibilities is aroused when a subject knows he will see pairs of pictures than when he knows he will see pairs of words, the selective effects of priming physically identical pairs may occur only for conditions in which the subject receives only pictures or only words. In fact, in the previous experiments, only such conditions were used. If, however, the set of probable occurrences for the category is in a common form representing an underlying meaning of the category name, differential effects of priming should still occur under conditions in which word and picture pairs are mixed and the subject does not know for any given trial whether the pair he is about to see will be a pair of words or a pair of pictures. This condition was explored in the present experiment.

Method

Subjects

Subjects were 30 paid student volunteers who had not participated in any of the previous priming experiments.

Stimuli and Procedure

Stimuli were the words and pictures of Set 1 used in Experiment 2. Because a double set of stimuli was being used, conditions of testing other than the variable of interest (the subject's uncertainty as to whether a pair of words or pictures would be presented) were unavoidably introduced. To control for these extraneous variations, two types of stimulus set and conditions of testing were employed.

In the first type of testing, a single subject was given both the Set 1 word and picture stimuli of Experiment 2. Thus, each subject received one more replication and twice as many stimuli as subjects had received in Experiments 2 and 4. The second type of testing employed matched pairs of subjects, each of which received half of the double stimulus set. The sets for this testing were prepared to maximize similarity to the type of set each subject had received in Experiments 2 and 4.

For the first type of testing, a stimulus set consisted of all of the words and all of the pictures

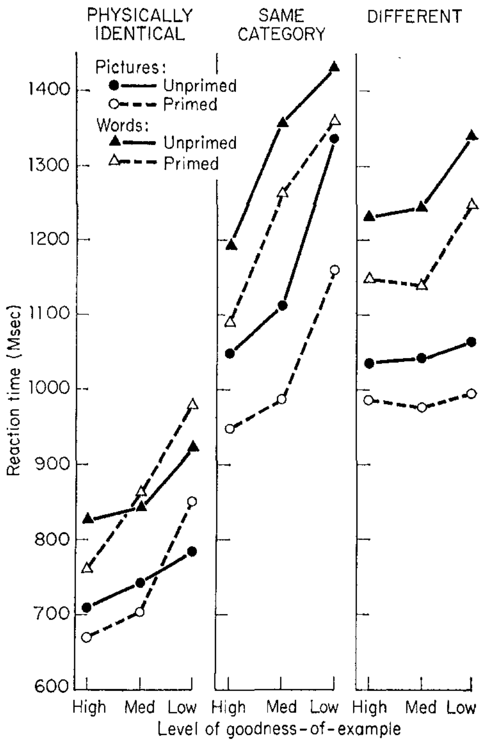

FIGURE 5. Words and pictures together, same-category instructions, 2-sec prime interval.

of Set. 1. These were administered with the same procedures used in Experiment 2 with the exception that for each trial the subject did not know whether he would see a pair of words or of pictures. Because subjects were receiving a double set, each pair occurred four rather than two times; once as a pair of primed pictures, once as unprimed pictures, once as primed words, and once as unprimed words. The test session lasted 4 hr. Subjects were tested on 2 successive days and were paid for their services. Ten subjects participated in this testing procedure.

For the second type of testing, 36 subjects were initially screened in a 15-min pretesting session which consisted of a brief test of simple visual reaction time and a brief priming task of the same design as the present study but using different categories and items. On the basis of scores on these tests, it was possible to select 10 matched pairs of subjects whose reaction times had been most similar in the initial screening session. Each member of a pair received half of the randomly ordered double set of stimuli with the following constraints on randomness: Each subject received all of the items of Set 1; exactly half of the pairs were in the form of words and half in the form of pictures. The matched subject of a pair received all of the items of Set 1 equally divided into pairs of words and pictures; however, all items which the first subject had received as words, the second subject received as pictures and vice versa. Which items were words and which pictures varied for each of the 10 pairs of subjects. Different random orders of presentation were used for each pair of subjects, but the two subjects in a matched pair received the same order.

Instructions and practice trials were modified to include the fact that pairs could now be either words or pictures but were otherwise identical to those used in Experiment 2. Testing procedures also were as described in Experiment 2.

Results and Discussion

Results were analyzed in the manner described for Experiment 2: separately for the group of subjects who had received both sets and for the matched group in which each subject had received a half set. In the latter case, each matched pair was treated as a single subject in the analysis. The pattern of results and the effects which reached significance were identical for both groups. The only difference between the groups was in overall reaction time; subjects who had received both sets with 4 hr of testing showed a faster mean reaction time in all conditions than subjects for whom each item had not been replicated and who had been tested for only 2 hr. Because the conditions of testing for each matched-pair subject approximated those of Experiment 2 more closely than the testing conditions of the double-set subjects, and because the fact of having two subjects per set did not appear to affect results, it is the results from the matched pairs which are presented and discussed below.

Results for Experiment 6 are shown in Figure 5. Overall error rate was 6%; as in previous experiments, there were no significant differences in error rates for any condition. The results are, in all important respects, identical to those of Experiment 2. Results were analyzed in the same manner as that described for Experiment 2. For the physically identical stimuli, for both pictures and words, the Priming × Level of Goodness of Example interaction was significant: pictures, $F(2, 18) = 8.42$, $p < .01$; words, $F(2, 18) = 8.14$, $p < .05$. T tests established that priming significantly helped good examples: pictures, $t(9) = 2.30$, $p < .05$; words, $t(9) = 2.47$, $p < .05$;

and hindered poor examples: pictures, $t(9) = 3.27$, $p < .01$; words, $t(9) = 2.51$, $p < .05$.

For the same-category pairs, results were also equivalent to Experiments 2 and 3. The Priming × Level of Goodness of Example interaction was not significant. Main effects of priming were significant: pictures, $F(1, 9) = 20.67$, $p < .01$; words, $F(1, 9) = 10.88$, $p < .01$. The effects of level of goodness of example were significant: pictures $F(2, 18) = 18.34$, $p < .001$; words, $F(2, 18) = 22.58$, $p < .001$. As usual, main effects of category reached significance but did not interact with the other variables.

For the different responses, results were, likewise, very like those of Experiments 2 and 4. The main effect of priming was significant: pictures, $F(1, 9) = 5.91$, $p < .05$ (min F' not significant); words, $F(1, 9) = 11.00$, $p < .01$. The main effect of level of goodness of example was significant: pictures, $F(2, 18) = 4.18$, $p < .05$ (min F' not significant); words, $F(2, 18) = 8.41$, $p < .01$. The Priming × Level of Goodness of Example interaction was not significant. Effects of category reached significance for words and not pictures but did not interact with the other variables.

In order to test further whether seeing word stimuli only and picture stimuli only versus seeing both in the same experimental paradigm affected any of the factors for physically identical pairs, a mixed-model four-way ANOVA (Words & Pictures Separate vs. Words & Pictures Together × Priming × Level of Goodness of Example × Category) was performed on the results for physically identical pairs for Set 1 stimuli of Experiments 2 and 7. Words and pictures separate (Experiment 2) versus words and pictures together (Experiment 7) was a between-subjects variable; the other variables were within subjects. Separate analyses were, necessarily, performed on words and on pictures since the variable of interest required that words and pictures be a between-subjects variable in Experiment 2 and a within-subjects variable in Experiment 7. The result of interest from this analysis was that none of the interactions between words and pictures together versus words and pictures separate reached significance.

The present experiment was not designed to show that there was no possible differentiation between pictorial and verbal coding of the underlying meaning of category representations. It did demonstrate clearly, however, that within a time interval of 2 sec, subjects were capable of generating a representation of the type of semantic category used in the present studies which showed selective effects of priming on words and pictures in a manner identical to the effects shown when subjects knew they would see only pictures or only words. What sort of representation is this? The results of the present experiment support the idea that the representation is not entirely specific to either a pictorial or verbal mode but is some set of abstract probabilities of items that can represent the meaning of the category in either mode. Yet there may be some aspect of the representation which is specific to pictures and to words which was masked in the present experiment by a priming interval which was long enough for both specific codes to be generated. The purpose of Experiment 8 was the further examination of the time course of generation of the representation both for pictures and words presented alone and presented together.

Experiment 8

In Experiments 2 and 7, a 2-sec time interval occurred between the prime and presentation of the stimulus pair. This interval may well have been long enough for subjects to generate all aspects of the relevant category representation so that they would be prepared for underlying meaning represented in the form either of pictures or words. The purpose of the present experiment was to observe the effects of systematic reduction of the time interval between the prime and the stimulus.

Method

Subjects

A total of 200 subjects were tested. Of these, 100 were tested in conditions in which words and

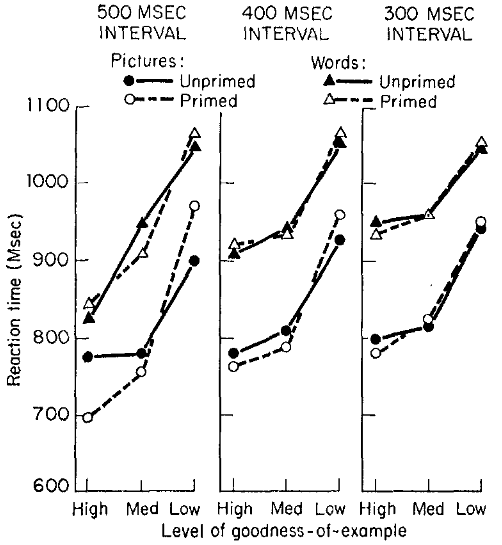

FIGURE 6. Conditions of "uncertainty," varying prime interval, words and pictures together.

pictures were presented separately; these subjects were students in introductory psychology courses who had not participated in previous priming experiments and who received course credit for participation. Subjects who were tested in the condition where words and pictures were both presented were obtained in the same manner as matched pairs had been obtained in Experiment 7. For each group of 10 matched pairs required, 40 paid volunteers were pretested as described in Experiment 7. Twenty students were selected who formed pairs best matched in reaction time; these 20 subjects participated as paid volunteers in that part of the priming experiment itself.

Stimuli and Procedure

The stimuli consisted of Set 1 of Experiment 2. For the words only and pictures only groups, procedures were as described in Experiment 2 with the exception that, as in Experiment 4, subjects did not repeat the prime or the word *blank*. Stimulus sets were prepared for the words plus pictures groups as described in Experiment 7.

Five intervals of time between the prime and presentation of the pair were used: 500 msec, 400 msec, 300 msec, 200 msec, and 100 msec. In order to provide greater accuracy and consistency of the intervals, the primes and word *blank* were recorded on a Wallensac tape recorder in different prearranged random orders for each subject. Stimulus cards were rearranged for each subject to match the order on the tape. The experimenter initiated each trial after he had positioned the appropriate card in the tachistoscope by pressing a foot pedal which began the tape. The tape played the prime or *blank* and, as the word was terminated, initiated the required time interval before the stimulus appeared. After initiating the time interval, the tape stopped until the experimenter initiated the succeeding trial.

At each of the five time intervals, 10 subjects were tested under the words only condition, 10 subjects under the pictures only condition, and 10 matched pairs of subjects under the words plus pictures condition.

Results

The results for the physically identical pairs of each condition at each time interval are shown for conditions of uncertainty in Figure 6 and for conditions of certainty in Figure 7. (Figure 6 does not show results for the 200- and 100-msec conditions because of their similarity to the 300-msec condition.) Overall error rate was 5%, and, as previously found, did not differ significantly in any condition. Results were analyzed as previously described in Experiments 2, 4, and 7, separately for words and for pictures, in each condition, and at each time

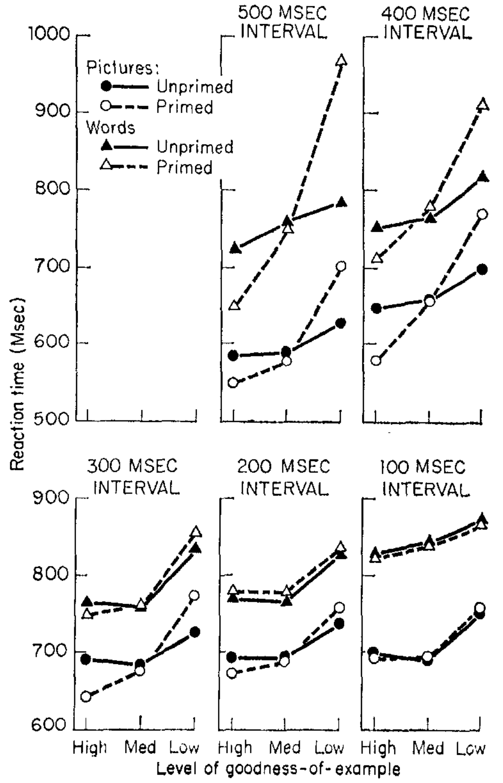

FIGURE 7. Conditions of "certainty," varying prime interval, words and pictures separate.

TABLE 3

TIME COURSE FOR GENERATION OF PHYSICALLY IDENTICAL STIMULI

Stimulus interval (in msec)	Picture: Interaction F^a	Picture: t test[b] High GOE	Picture: t test[b] Low GOE	Word: Interaction F^a	Word: t test[b] High GOE	Word: t test[b] Low GOE
			Certainty			
500	8.16**	2.47*	3.80**	20.61***	3.85**	5.62***
400	10.06**	2.42*	2.56*	9.84**	2.78*	4.02**
300	5.26*	2.50*	2.71*	3.90*	2.17	1.99
200	4.19*	2.21	2.08	.93	.23	.09
100	3.06	1.83	.05	.78	.66	.34
			Uncertainty			
500	7.82**	4.20*	2.84*	2.32	1.03	2.01
400	5.58*	1.88	2.16	1.96	1.14	.92
300	3.20	2.17	.19	2.76	.63	1.01
200	2.35	1.51	1.94	1.90	1.04	.82
100	1.59	1.07	1.23	1.86	.56	.07

Note. GOE = goodness of example.
[a] $df = 2, 18$.
[b] $df = 9$.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

interval. Results of significance tests of relevance to the present experiment are shown in Table 3. Table 3 shows the results of the ANOVAs for the Priming × Level of Goodness of Example interaction and the results of t tests for the significance of the facilitation (speeding of responses) provided by the prime for good examples and the interference (slowing of responses) provided by the prime for poor examples. Other tests of the significance of effects in Experiment 8 are not included in Table 3.[8]

The pattern of relevant results was quite clear and extremely orderly. It required more time (a longer time interval between the prime and presentation of the stimulus) to generate a representation capable of selectively affecting responses to the physically identical pairs under conditions of uncertainty than under conditions of certainity. And it required a longer time interval to generate a representation capable of those selective effects when the stimuli were words than when they were pictures. The two effects appeared to be additive (see Sternberg, 1969).

Each of the effects will be summarized separately. The effect of uncertainty is apparent: A consistently longer time interval was required between prime and stimulus for effects to be obtained under conditions of uncertainty than under conditions of certainty (the words only and pictures only condition). At a 500-msec interval, under conditions of uncertainty, the expected effect for the word stimuli (a significant Priming × Level of Goodness of Example interaction) was not significant; however, at this same time interval, under conditions of certainty (words only and pictures only), all effects were identical to those achieved at a 2-sec interval (that is, expected effects for all stimuli were achieved). At the 400-msec interval, in conditions of uncertainty, not only were the effects for the word stimuli not significant, but the effects for

[8] In fact, consistent main effects of level of goodness of example were obtained in all cases; however, such main effects are not relevant to the particular questions which the present experiment was designed to test. Similarly, some category effects were significant but did not interact with the effects of interest to the present hypothesis. Results for the same-category and different items (which, it should be remembered, are not affected by priming interval) were virtually identical, in the present studies, to the results found for those conditions in Experiments 2 and 4; these data are also irrelevant to the hypothesis of the present study and are not presented.

the picture stimuli were diminished; that is, although the Priming × Level of Goodness of Example interaction reached significance, neither of the *t* tests for specific effects of facilitation and suppression of response were significant. At that same 400-msec interval, effects in the two conditions of stimulus certainty were still the same as they had been at the 2-sec interval; all expected effects were obtained. At the 300-msec interval and at all shorter intervals, no significant effects at all were achieved in conditions of uncertainty, although a pattern of significant effects continued to be found for some stimuli under conditions of stimulus certainty at the 300-msec and 200-msec intervals.

The effect of mode of representation (pictures or words) was apparent; it required a consistently longer time interval between prime and stimulus for effects to be obtained for word stimuli than for picture stimuli. This difference between words and pictures was obtained both under conditions of uncertainty and of certainty. Under conditions of uncertainty, at the 500-msec interval, the expected Priming × Level of Goodness of Example interaction was not significant for the words stimuli; however, that interaction was as large for the pictures stimuli as it had been at the 2-sec interval. At the 400-msec interval under conditions of uncertainty, there was, not surprisingly, also no significant Priming × Level of Goodness of Example interaction for the words stimuli; for the pictures stimuli, however, although the effects of priming were diminished (*t* tests for specific effects of facilitation and suppression of responses were not significant), the overall Priming × Level of Goodness of Example interaction was still significant.

Under conditions of certainty, effects for both words and pictures at 500 msec and 400 msec were as they had been at the 2-sec interval. However, at the 300-msec interval, the effect of priming on the words stimuli was diminished; that is, the Priming × Level of Goodness of Example interaction attained significance but neither of the *t* tests for facilitation of good examples and inhibition of poor examples was significant. At this same 300-msec interval, the pictures stimuli still exhibited the same effects as had been found at the longer time intervals. At the 200-msec interval, no effects at all were significant for the words stimuli; however, at this time interval effects were found for the pictures stimuli in their diminished form.

At the 100-msec interval, no effects either of words or pictures under conditions either of certainty or uncertainty were significant, the same results which had been obtained for priming of physically identical pairs in Experiment 4 when the prime and stimulus were presented simultaneously.

In conclusion, the results of Experiment 7 had appeared to indicate that representations of words and pictures were derived from a single underlying meaning since, within 2 sec, subjects could generate a representation of the meaning of the category name which was as effective under conditions of uncertainty as it was under conditions of certainty. However, the present experiment has shown that when the time interval between the prime and the stimulus is reduced below some minimum (by extrapolation probably 600 or 700 msec), an element of differentiation in the representations of words and pictures is revealed by differences in the time intervals required to generate representations. Generation of both representations (i.e., generation under conditions of uncertainty) requires longer processing time than generation of a representation of either words or pictures alone; and generation of a representation capable of selective effects on word stimuli requires longer processing time than generation of a representation which will affect pictures. Thus, we may tentatively conclude that while there is considerable similarity in the depth meaning of superordinate categories not specifically coded in terms of words or pictures, there is some differentiation of the format into which the meaning is translated in preparation for the perception of actual words or pictures. The fact that less time is required to prepare for pictures suggests very tentatively that pictures may be closer to the nature of the underlying representation than are words.

Experiment 9

In Experiment 1, reliable ratings of the goodness of example of category members were obtained for nine semantic categories, and in subsequent experiments consistent and explainable effects of those norms of level of goodness of example were obtained. Similar consistent selective effects of priming on good and poor examples of color categories were obtained by Rosch (in press-d). For color categories, good examples retained an advantage when primed over poor examples even after long practice with a limited set of stimuli. These results were taken as an additional form of evidence that goodness of example in color categories may be partly physiologically determined by the salience of certain areas of the color space. There is no reason to think that good examples of the semantic categories used in the present study are determined by perceptual saliency in the same manner as are prototypes for color categories. That is, while the internal structure of categories may be determined by psychological principles which are not arbitrary (Rosch, 1975), it seems unlikely that good examples of semantic categories are attached to the category name more strongly than poor examples in a manner which cannot be altered by sufficient practice. The present experiment attempted to duplicate as closely as possible the practice conditions of Rosch (in press-d).

The purpose of Experiment 9 was twofold: In part it was intended as a comparison between semantic categories and color categories. It was expected that good examples of semantic categories would not retain an advantage over poor examples given the amount of practice in which good examples of color categories had retained an advantage over poor ones. The second purpose of the experiment was a methodological point, the demonstration that effects obtained with artificial categories, even when they are comprised of a set of real words redefined into a new artificial set, can give misleading information concerning the nature of actual natural categories.

Method

Rosch (in press-d) used as stimuli 16 colors—8 good and 8 poor examples of the 8 basic color name categories—and used physical identity instructions. In the present study, it was necessary to use same-category instructions (as shown by the results of Experiment 5). In order to have an equivalent 16 stimuli, only 4 categories were used per subject and only the good and poor (omitting the intermediate) examples of each category were used. Four subjects were selected for the task and were paid for their services. One subject received word stimuli and one received picture stimuli for the 4 good and 4 poor examples shown in Table 1 for Set 1 of furniture, fruit, vehicle, and sport. The other two subjects received the good and poor examples of Set 1 for the categories: weapon, vegetable, bird, and carpenter's tool; one subject received words, the other pictures.

The instructions and procedures used in Experiment 2 were followed. Practice trials were modified to take into account the reduced set of stimuli being used. Following the procedures used for the color categories, each subject was tested 21 times on the same small set of stimuli. After an initial session, subjects made 2 runs per day, 5 days per wk, for 2 wk.

Results and Discussion

Figure 8 shows the results for the the four subjects for the physically identical stimuli of their last test session. Overall error rate was .02%; there were no sig-

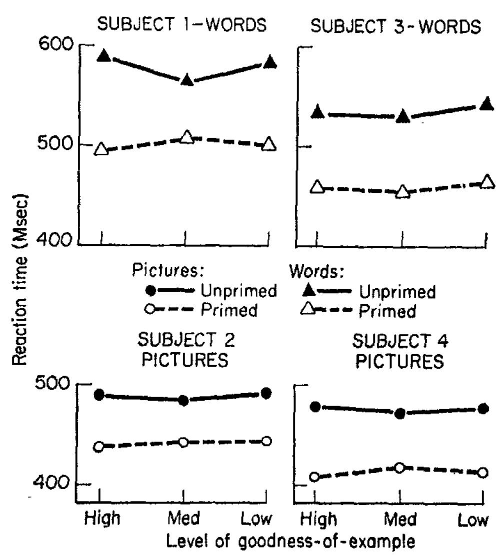

Figure 8. Effects of 2-wk practice on reduced set of stimuli.

nificant differences in error rate in any condition. By this session the Priming × Goodness of Example interaction and the main effect of goodness of example appear to have disappeared. To test whether that was in fact the case, following the procedures of analysis used by Rosch (in press-d), a within-subjects ANOVA was performed for each subject with cell variance supplied by the six different responses for each item supplied by the last six test runs of that subject. In all cases, the main effect of priming was significant—Subjects 1–4, respectively: $F(1, 5) = 9.23$, $p < .05$; $F(1, 5) = 10.71$, $p < .05$; $F(1, 5) = 6.17$, $p < .05$; $F(1, 5) = 5.97$, $p < .05$ (min F' not significant). In summary, in no case were the Priming × Goodness of Example interaction and the main effect of goodness of example significant. This result is not found for the physically identical pairs in any of the other experiments in this study.

Subjects' descriptions of their behavior in the experiment were quite similar: All four reported that they quickly memorized the possible stimuli (words or pictures), and when primed, formed an image of the two possible words or pictures. Such an account (we may replace *image* with *expectation* if greater theoretical neutrality is desired) would lead to the obtained data. As predicted, the names of the categories acquired a new meaning; they now named artificial sets consisting of two specific possible stimuli. It should be noted that the new categories were now no longer necessarily at a superordinate level of abstraction which had been the level of their natural meaning but now may have been at a basic or subordinate level for which different effects of priming can be expected (Rosch et al., in press).

This experiment has shown that the internal structure of semantic categories, although consistent and pervasive in the processing of natural categories, can, unlike the internal structure of color categories, be readily altered by practice and by task demands. The present experiment demonstrates how easily a very general effect obtained with natural semantic categories can be eliminated when experimental structure changes those categories into artificial categories.

General Discussion

The present research is part of a general investigation of the nature of human categorization. The part of the work reported in this paper was concerned with one important type of category, that into which the common concrete objects of the real world are classified, and with one type of question about such categories, the structure of the representations which the human mind generates when a human subject hears a category term and understands its meaning.

The set of categories which were used in the investigation represent virtually the entire population of common higher-order (superordinate) classifications of concrete objects with the restriction that the categories not be embedded in idiosyncratic taxonomic structures (*common* and *taxonomic* structure were operationally defined in Experiment 1). It should be noted that these are some of the categories which have been most commonly used in psychological studies of learning. This research was specifically not designed to investigate abstract concepts of the type represented by words such as *beauty* or *causality*. The research also did not directly investigate representations of specific exemplars (members) of higher order superordinate categories, although part of the purpose of the present experiments was to make possible a comparison of representations of superordinate categories with representations of categories of other types and at other levels of abstraction (Rosch, in press-d; Rosch et al., in press).

There were four basic findings from the present series of experiments. First, the internal structure of superordinate semantic categories was clearly a pervasive aspect of the way in which those categories were processed in the tasks used. For responses to physically identical stimuli, the internal structure of the categories appeared to be a part of that cognitive representation of the category aroused prior to presentation of the stimuli which affected subjects' perception of the stimuli. In this case, cognitive representations of categories clearly contained more of the information needed to respond to category members which had been rated good examples of the category in Experiment 1 than to respond to category members which had been rated bad examples. In other words, cognitive representations of categories appeared to be more similar to the good examples than the poor examples.[4] An account of the meaning of superordinate category names by means of a definitive list of attributes or features necessary and sufficient for category membership requires considerable additional explanation to account for such findings. While it may still be argued that the "true" meaning of such category names must reside in philosophical or linguistic primitives consisting of feature lists of that nature, the present study offers evidence that such accounts do not appear to mirror psychological reality.

In line with that point, it should be noted that the research reported in this article was not intended either as a model of semantic memory or as a verification or refutation of any particular theory of semantic memory. Indeed, as was shown in the discussion of same-category and different items in Experiment 4, the priming technique appears to be a poor tool for distinguishing among alternative models of decision processes concerning category membership. Nonetheless, the findings of the present research are more compatible with some classes of semantic memory theory than with others. It is relatively difficult to integrate the present findings with models of semantic memory which depend on criterial features and clear-cut category boundaries (such as that of Glass & Holyoak, in press). On the other hand, the attribute theory of Smith et al. (1974), which is based on structures such as those explored in the present research, is necessarily compatible with those structures. And a theory such as that of Collins and Loftus (in press), which has as its basis the analogue process of spreading activation, fits well with the present research, at least in the sense that it is relatively easy to describe many of the "structural" findings of the present studies using the "process" terminology of spreading activation.

It is important to note that the basic findings of the present study are not dependent for their validity upon any particular interpretation of the meaning of internal structure (e.g., of the norms shown in Table A1). It may be argued that such norms merely reflect word frequency (which the norms in fact, do not—Mervis, Rosch, & Catlin, Note 3), associative strength to the category name, frequency of the actual objects in the category, or co-occurrence frequency with the category name. That these are not viable as complete accounts of the meaning of internal structure and that, in fact, the actual structure of the attributes of category members is involved in goodness of example norms is argued by several lines of ongoing research (Rosch, in press-a; Rosch & Mervis, in press; Rosch et al., in press; Rosch, Simpson, & Miller, Note 1; Mervis et al., Note 3). However, regardless of its interpretation, the effects of the internal structure of categories in perceptual tasks found by the present study both constitute a refutation of the psychological reality of an Aristotelian view of categories and make possible the further investigation of the nature of the cognitive representation generated by the category name which affected perception of stimuli.

Subsequent experiments of the present research focused on the issue of the nature of effects on perception generated by superordinate category terms. The second basic finding concerned levels of processing in perception (Cohen, 1968; Posner & Mitchell, 1967; Beller & Schaeffer, Note 2). Experiments 5 and 6 showed that the selective effects of internal structure on perception of physically identical pairs could not

[4] Although for same-category and different stimuli it was not possible to isolate encoding from decision effects, it should be noted that effects of internal structure were also apparent in the results for these conditions and were in no place contradictory to effects of category structure previously found in tasks requiring search and retrieval from semantic memory (Collins & Loftus, in press; Rips et al., 1973; Rosch, 1973; Smith et al., 1974).

be accounted for by concrete physical features present in the representation generated by the category name. Therefore, by the logic outlined in the discussion sections of Experiments 5 and 6, the effects of the representation on perception must have been due to the abstract representation of the meaning of the category name. Such a finding demonstrates, by means of a specific operation, that, at least at one level of perception, the meaning of pictures and of words is part of the actual perception of the stimuli and not something inferred after the perception occurs. The nature of such meaning appeared to be in the form of an abstract ordered set of inclusion probabilities of the meanings of members of the category with the probabilities ordered according to the internal structure of the category.

The fact that meaning itself could be inferred to affect perception of a stimulus pair and that the identical design could be used for pairs of words and pictures made possible the investigation which led to the third basic finding of the research which concerned the nature of the underlying representation of the meaning of words and pictures. Experiments 7 and 8 explored the question of whether the representation of words and pictures was derived from a common meaning or from dual codes specific to the modality of the stimulus. The results indicated the partial truth of both formulations. Sufficient underlying meaning appeared to be common to words and pictures that, within 2 sec (by extrapolation from Experiment 8, within 700 msec), subjects can generate a representation of the meaning of the category name which is equally representative of a pair of words or pictures under conditions in which the subject is uncertain as to the type of stimulus which is to appear. However, when the time intervals between the prime and the stimulus are reduced below this minimum, an element of differentiation in the representations of words and pictures is revealed by differences in the time intervals required to generate representations. Generation of both representations (that is, generation of a representation under conditions of uncertainty) requires a longer time interval than generation of a representation for either words or pictures alone (i.e., under conditions of certainty), and generation of a representation capable of selective effects on word stimuli requires a longer interval than generation of a representation which will affect pictures. Thus, we may conclude, tentatively, that there is a depth meaning of superordinate categories not specifically coded in terms of words or pictures, but that the depth meaning is translated into a format in preparation for actual perception which differs slightly for words and pictures. The fact that less time is required to prepare for pictures suggests that pictures may be closer to the nature of the underlying representation than are words.

The fourth finding of the present research is the comparison which it made possible between representations generated by category names of different types (such as color vs. semantic categories) and of categories at different levels of abstraction. Color category names appeared to generate a concrete physical representation, and there was no evidence of a semantic meaning additional to the physical representation (Rosch, in press-d). Names of the members of superordinate categories (more specifically basic level and subordinate category names, Rosch, in press-a; Rosch et al., in press) also appear capable of generating concrete physical representations at a level at which superordinate category names did not generate physical features.

Levels of abstraction have been defined and studied by a variety of different means such as logic (Kay, 1971); a variety of empirical ratings of levels of abstractness (Kammann & Streeter, 1971; Paivio, 1971); effects of rated levels on learning and memory (Paivio, 1971); and levels of abstractness defined in terms of sub- and superordinations to basic level classifications (Rosch, in press-a; Rosch et al., in press). Arguments over whether the language of a child develops by becoming more or less abstract have received considerable attention (Anglin, 1970; McNeill, 1966). The present method makes possible a detailed investigation of the nature of the mental representations generated by category terms at any level of abstraction. The addition of such knowledge may make possible a greater understanding of the nature of psychological representation, the nature of taxonomies, and the process of abstraction.

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Appendix

TABLE A1: Norms for Goodness-of-Example Rating for Nine Semantic Categories

Member	Goodness of example Rank	Specific score	Member	Goodness of example Rank	Specific score
		Furniture			
chair	1.5	1.04	lamp	31	2.94
sofa	1.5	1.04	stool	32	3.13
couch	3.5	1.10	hassock	33	3.43
table	3.5	1.10	drawers	34	3.63
easy chair	5	1.33	piano	35	3.64
dresser	6.5	1.37	cushion	36	3.70
rocking chair	6.5	1.37	magazine rack	37	4.14
coffee table	8	1.38	hi-fi	38	4.25
rocker	9	1.42	cupboard	39	4.27
love seat	10	1.44	stereo	40	4.32
chest of drawers	11	1.48	mirror	41	4.39
desk	12	1.54	television	42	4.41
bed	13	1.58	bar	43	4.46
bureau	14	1.59	shelf	44	4.52
davenport	15.5	1.61	rug	45	5.00
end table	15.5	1.61	pillow	46	5.03
divan	17	1.70	wastebasket	47	5.34
night table	18	1.83	radio	48	5.37
chest	19	1.98	sewing machine	49	5.39
cedar chest	20	2.11	stove	50	5.40
vanity	21	2.13	counter	51	5.44
bookcase	22	2.15	clock	52	5.48
lounge	23	2.17	drapes	53	5.67
chaise lounge	24	2.26	refrigerator	54	5.70
ottoman	25	2.43	picture	55	5.75
footstool	26	2.45	closet	56	5.95
cabinet	27	2.49	vase	57	6.23
china closet	28	2.59	ashtray	58	6.35
bench	29	2.77	fan	59	6.49
buffet	30	2.89	telephone	60	6.68
		Fruit			
orange	1	1.07	papaya	27	2.58
apple	2	1.08	honeydew	28	2.73
banana	3	1.15	fig	29	2.86
peach	4	1.17	mango	30	2.88
pear	5	1.18	guava	31	3.03
apricot	6.5	1.36	pomegranate	32	3.05
tangerine	6.5	1.36	cranberry	33.5	3.22
plum	8	1.37	passion fruit	33.5	3.22
grapes	9	1.38	prunes	35	3.30
nectarine	10	1.52	gooseberry	36	3.33
strawberry	11	1.61	date	37	3.35
grapefruit	12	1.77	kumquat	38	3.39
berry	13	1.82	raisin	39	3.42
cherry	14	1.86	muskmelon	40	3.48
pineapple	15	1.19	persimmon	41	3.63
blackberry	16	2.05	pawpaw	42	4.30
melon	17	2.09	coconut	43	4.50
blueberry	18	2.14	avocado	44	5.37
raspberry	19	2.15	pumpkin	45	5.39
lemon	20	2.16	tomato	46	5.58
black raspberry	21	2.21	nut	47	6.01
boysenberry	22	2.38	gourd	48	6.02
watermelon	23	2.39	olive	49	6.21
cantaloupe	24	2.44	pickle	50	6.34
lime	25	2.45	squash	51	6.55
tangelo	26	2.50			

TABLE A1—(*Continued*)

Member	Goodness of example: Rank	Goodness of example: Specific score	Member	Goodness of example: Rank	Goodness of example: Specific score
Vehicle					
automobile	1	1.02	subway	26	3.32
station wagon	2.	1.14	trailer	27	3.50
truck	3	1.17	cart	28	3.55
car	4	1.24	wheelchair	29	3.68
bus	5.5	1.27	yacht	30	3.76
taxi	5.5	1.27	tank	31	3.84
jeep	7	1.35	go-cart	32	3.85
ambulance	8	1.62	rowboat	33	3.92
motorcycle	9	1.65	dogsled	34	3.95
streetcar	10	1.90	tricycle	35	4.00
van	11	1.95	canoe	36	4.01
Honda	12	2.03	raft	37	4.37
cable car	13	2.11	submarine	38	4.51
train	14	2.15	sled	39	4.61
trolley (car)	15	2.19	horse	40	4.63
bicycle	16	2.51	rocket	41	4.74
carriage	17	2.59	blimp	42	4.81
airplane	18	2.64	skates	43	4.99
bike	19	2.73	camel	44	5.22
boat	20	2.75	feet	45	5.34
jet	21	2.79	skis	46	5.40
ship	22	2.82	skateboard	47	5.54
scooter	23	3.24	wheelbarrow	48	5.72
tractor	24	3.30	surfboard	49	5.78
wagon	25	3.31	elevator	50	5.90
Weapon					
gun	1	1.03	ice pick	31	3.14
pistol	2	1.07	hatchet	32	3.16
revolver	3	1.09	slingshot	33	3.29
machine gun	4	1.16	fists	34	3.31
rifle	5	1.17	axe	35	3.34
switchblade	6	1.35	bow	36	3.44
knife	7	1.40	razor	37	3.82
dagger	8	1.41	razor blade	38	3.83
shotgun	9	1.46	rocket	39	3.90
sword	10	1.47	judo	40	3.94
bomb	11.5	1.61	stick	41	4.04
hand grenade	11.5	1.61	poison	42	4.07
A-bomb	13.5	1.69	rock	43	4.18
bayonet	13.5	1.69	stone	44	4.26
spear	15	1.70	gas	45	4.31
bazooka	16	1.76	chain	46	4.45
cannon	17	1.96	scissors	47	4.50
bow and arrow	18	1.98	bricks	48	4.64
club	19	2.09	pitchfork	49	4.67
lance	20	2.14	hammer	50	4.78
brass knuckles	21	2.38	words	51	4.93
bullet	22	2.44	hand	52	5.01
tomahawk	23	2.48	pipe	53	5.04
mortar	24	2.56	rope	54	5.08
arrow	25	2.66	airplane	55	5.09
blackjack	26	2.68	foot	56	5.23
tank	27	2.74	car	57	5.31
teargas	28	2.88	screwdriver	58	5.40
missile	29	2.90	glass	59	5.60
whip	30	3.11	shoes	60	6.23

TABLE A1—(*Continued*)

Member	Goodness of example Rank	Specific score	Member	Goodness of example Rank	Specific score
		Vegetable			
pea	1	1.07	potato	29	2.89
carrot	2	1.15	parsnip	30	2.91
green beans	3	1.18	turnip greens	31	2.95
string beans	4	1.21	collard	32	2.99
spinach	5	1.22	wax beans	33	3.02
broccoli	6	1.28	watercress	34	3.04
asparagus	7	1.41	blackeyed peas	35	3.06
corn	8	1.55	leek	36	3.15
cauliflower	9	1.62	peppers	37	3.21
brussels sprouts	10	1.72	sweet potato	38	3.27
squash	11	1.83	yams	39	3.31
lettuce	12	1.85	parsley	40	3.32
celery	13	1.90	endive	41	3.39
cucumber	14	2.05	rutabaga	42	3.42
beets	15	2.08	mushroom	43	3.56
greens	16	2.18	avocado	44	3.62
tomato	17	2.23	rhubarb	45	3.66
lima beans	18	2.28	kale	46	3.67
artichokes	19	2.32	escarole	47	3.90
turnip	20	2.37	sauerkraut	48	4.18
eggplant	21	2.38	pickles	49	4.57
romaine	22	2.44	baked beans	50	4.73
green peppers	23.5	2.49	pumpkin	51	4.74
okra	23.5	2.49	seaweed	52	5.04
radishes	25	2.51	garlic	53	5.07
onions	26	2.52	dandelion	54	5.20
bean	27	2.54	peanut	55	5.56
green onion	28	2.60	rice	56	5.59
		Carpenter's tool			
saw	1	1.04	blueprints	31	2.90
hammer	2	1.34	brace	32	2.92
ruler	3	1.48	awl	33	3.09
screwdriver	4	1.56	crowbar	34.5	3.12
drill	5	1.59	hinge	34.5	3.12
nails	6	1.67	miter box	36	3.23
tape measure	7	1.69	knife	37	3.44
sawhorse	8	1.77	chalk	38.5	3.50
sandpaper	9	1.78	nuts	38.5	3.50
sander	10	1.79	bolts	40	3.63
level	11	1.82	plumb line	41	3.65
plane	12	1.91	brush	42.5	3.74
file	13	2.01	sledge hammer	42.5	3.74
toolbox	14	2.12	glue	44	3.79
T-square	15	2.22	paintbrush	45	3.81
chisel	16	2.26	varnish	46	3.91
rasp	17	2.37	apron	47	4.06
pencil	18	2.39	stapler	48	4.21
hacksaw	19	2.41	extension cord	49	4.29
square	20	2.44	soldering iron	50	4.39
bench	21	2.50	plaster	51.5	4.43
pliers	22	2.59	wheelbarrow	51.5	4.43
wrench	23	2.60	axe	53	4.53
ladder	24	2.64	slide rule	54	4.57
lathe	25	2.75	cement	55	4.91
vise	26	2.76	anvil	56	5.10
screws	27.5	2.77	hatchet	57	5.15
wood	27.5	2.77	rags	58	5.20
wedge	29	2.80	scissors	59	5.36
lumber	30	2.84	crane	60	5.70

TABLE A1—(*Continued*)

Member	Goodness of example: Rank	Goodness of example: Specific score	Member	Goodness of example: Rank	Goodness of example: Specific score
Bird					
robin	1	1.02	goldfinch	28	2.06
sparrow	2	1.18	parrot	29	2.07
bluejay	3	1.29	sandpiper	30	2.40
bluebird	4	1.31	pheasant	31	2.69
canary	5	1.42	catbird	32	2.72
blackbird	6	1.43	crane	33	2.77
dove	7	1.46	albatross	34	2.80
lark	8	1.47	condor	35	2.83
swallow	9	1.52	toucan	36	2.95
parakeet	10	1.53	owl	37	2.96
oriole	11	1.61	pelican	38	2.98
mockingbird	12	1.62	geese	39	3.03
redbird	13.5	1.64	vulture	40	3.06
wren	13.5	1.64	stork	41	3.10
finch	15	1.66	buzzard	42	3.14
starling	16	1.72	swan	43	3.16
cardinal	17.5	1.75	flamingo	44	3.17
eagle	17.5	1.75	duck	45	3.24
hummingbird	19	1.76	peacock	46	3.31
seagull	20	1.77	egret	47	3.39
woodpecker	21	1.78	chicken	48	4.02
pigeon	22	1.81	turkey	49	4.09
thrush	23	1.89	ostrich	50	4.12
falcon	24	1.96	titmouse	51	4.35
crow	25	1.97	emu	52	4.38
hawk	26	1.99	penguin	53	4.53
raven	27	2.01	bat	54	6.15
Sport					
football	1	1.03	jai alai	31	2.30
baseball	2	1.05	skating	32	2.39
basketball	3	1.12	skindiving	33	2.40
tennis	4	1.15	sailing	34	2.44
softball	5	1.29	diving	35	2.50
canoeing	6	1.41	archery	36	2.54
handball	7	1.42	judo	37	2.63
rugby	8	1.43	car racing	38	2.78
hockey	9	1.44	ping pong	39	2.80
ice hockey	10	1.45	rowing	40	2.82
swimming	11	1.53	fishing	41	2.84
track	12	1.61	horseback riding	42	2.85
boxing	13	1.66	running	43	3.01
volleyball	14	1.71	horse racing	44	3.18
lacrosse	15	1.72	hiking	45	3.50
skiing	16	1.76	weight lifting	46	3.59
golf	17	1.77	croquet	47	3.60
polo	18	1.80	horseshoes	48	3.72
surfing	19	1.84	boating	49	3.75
wrestling	20	1.87	pool	50	3.82
gymnastics	21	1.88	billiards	51	3.95
cricket	22.5	1.99	hunting	52	4.05
squash	22.5	1.99	jump rope	53	5.00
badminton	24.5	2.08	camping	54.5	5.07
racing	24.5	2.08	chess	54.5	5.07
pole vault	26	2.09	dancing	56	5.49
fencing	27	2.13	checkers	57	5.64
bowling	28	2.18	cards	58	5.79
water skiing	29	2.22	sunbathing	59	6.75
ice skating	30	2.29			

TABLE A1—(*Continued*)

Member	Goodness of example: Rank	Goodness of example: Specific score	Member	Goodness of example: Rank	Goodness of example: Specific score
		Toy			
doll	1	1.41	balloon	31	3.07
top	2	1.48	skates	32	3.13
jack-in-the-box	3.5	1.61	baseball	33	3.18
toy soldier	3.5	1.61	drum	34	3.23
yo-yo	5	1.62	football	35	3.28
block	6	1.63	game	36	3.35
marbles	7	1.74	swing	37	3.35
rattle	8	1.79	boat	38	3.36
stuffed animal	9	1.87	monopoly	39	3.42
water pistol	10	1.88	sled	40	3.43
teddy bear	11	1.90	seesaw	41.5	3.48
rocking horse	12	1.91	stilts	41.5	3.48
doll house	13	1.95	checkers	43	3.56
ball	14	1.96	bat	44	3.62
jacks	15	2.09	car	45	3.63
paper dolls	16	2.14	airplane	46	3.66
erector set	17.5	2.16	bicycle	47.5	3.68
hula hoop	17.5	2.16	tractor	47.5	3.68
jump rope	19	2.29	sandbox	49	3.71
pogo stick	20	2.44	bike	50	3.77
clay	21.5	2.49	bow and arrow	51.5	4.20
wagon	21.5	2.49	rope	51.5	4.20
kite	23	2.51	dishes	53	4.51
train	24	2.59	cards	54	4.56
tricycle	25	2.61	mitt	55	4.77
coloring book	26	2.68	horse	56	4.97
crayons	27	2.71	gun	57	5.36
truck	28	2.78	animals	58	5.39
puzzle	29	2.82	tennis racket	59	5.40
fire engine	30	2.83	books	60	5.91
		Clothing			
pants	1	1.12	stockings	29	2.79
shirt	2.5	1.14	vest	30	2.81
dress	2.5	1.14	nylons	31	2.98
skirt	4	1.21	cape	32	3.38
blouse	5	1.27	boots	33	3.42
suit	6	1.45	sandals	34	3.56
slacks	7	1.49	tie	35	3.71
jacket	8	1.68	girdle	36	3.72
coat	9	1.88	belt	37	3.93
sweater	10	1.89	scarf	38	3.96
sweatshirt	11	1.95	mittens	39	3.99
underpants	12	2.01	slippers	40	4.08
sports jacket	13	2.05	hat	41	4.20
jumper	14.5	2.08	overshoes	42	4.42
panties	14.5	2.08	gloves	43	4.53
socks	16	2.13	apron	44	4.57
parka	17	2.19	earmuffs	45	5.04
pajamas	18	2.25	handkerchief	46	5.87
undershirt	19	2.26	purse	47	5.92
overcoat	20	2.29	hairband	48	5.98
nightgown	21	2.39	ring	49	6.11
raincoat	22.5	2.44	earrings	50.5	6.15
bathing suit	22.5	2.44	watch	50.5	6.15
bathrobe	24	2.65	cuff links	52	6.18
slip	25	2.67	necklace	53	6.21
bra	26	2.68	bracelet	54	6.24
shoes	27	2.73	cane	55	6.25
tuxedo	28	2.76			