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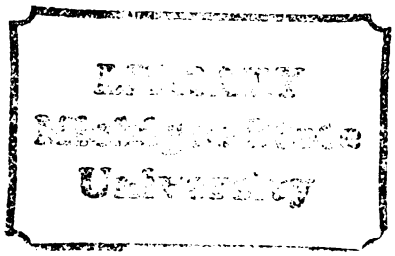

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GEORGES BORDAGE

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THE COGNITIVE STRUCTURE OF MEDICAL KNOWLEDGE:

CATEGORIES AND PROTOTYPES

By

Georges Bordage

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ABSTRACT

THE COGNITIVE STRUCTURE OF MEDICAL KNOWLEDGE:
CATEGORIES AND PROTOTYPES

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Recent investigations of the reasoning process in general and of medical reasoning in particular (for example, DeGroot, 1965; Elstein, Shulman, and Sprafka, 1978; and Barrows, Feightner, Neufeld, and Norman, 1978) have led to the conclusion that the factors that differentiate between excellent and weaker problem solvers are not to be found in differences in the strategies or thinking methods employed but rather in the content and organization of their knowledge stored in long-term memory. The organization of knowledge in memory can be conceived of in two ways: as rule-defined structures derived from a criterion and expressed within definite boundaries inside which all members have equal and full membership, or in terms of the category's best examples or clear cases with other members tending toward an order from better to poorer instances. Rosch (1978) refers to the clear cases as the prototypes. The purpose of this study is twofold: (1) to determine whether the concept of prototypes as developed by Rosch and co-workers is applicable to the structure of selected categories of medical disorders as stored in physicians' memory, and (2) to describe the influence of clinical experience on those structures.

Four experiments were conducted with 100 preclinical medical

students (two months prior to clerkships) and 77 experienced general practitioners to form a converging sequence of evidence concerning the internal structure of 14 broad categories of medical disorders. 1- Category norms: The list of disorders contained in the various categories was obtained separately from the two samples by means of a free-recall task. These lists were used as the taxonomic norms for the following experiments on internal structure. 2- Prototypicality ratings: Using a 7-point scale, the subjects were asked to rate the degree of exemplariness of eight disorders taken from each category. 3- Family resemblance: Lists of attributes (symptoms, signs, pathophysiological characteristics) for each disorder which had been rated for prototypicality were obtained by means of a free-recall task. Two hypotheses were tested about these attributes: (1) that the disorders with the highest prototypicality ratings in a category are those with the greatest number of attributes in common with the other disorders in the category, and (2) that each disorder in a category has at least one, if not several, attributes in common with one or more other disorders in the category, but none, or few, of the features are common to all disorders. 4- Response time: To test the effect of prototypicality on the cognitive processing of the categories, response times to verify category membership statements were obtained for disorders with high and low prototypicality ratings. The hypothesis was tested that the central members are recognized as members of their categories faster than the peripheral ones.

There were three basic and converging findings from this series of experiments. First, the striking structural feature of these categories, both for the students and the physicians, was not in the

presence of criterial attributes which defined the category and gave its members full and equal membership but rather in the presence of disorders that were perceived as having various degrees of membership and of many attributes common to some but not all the category members. The disorders within the categories were linked together by means of a network of overlapping features, the family resemblance relationship. The subjects meaningfully and reliably rated the various disorders for degree of examplariness and the higher the rating, the greater the number of attributes that disorder had in common with the remaining members of the category. Second, prototypicality did affect the cognitive processing of the categories. Verification of category membership was faster and more accurate for the central disorders than for the peripheral ones. Third, although clinical experience did not affect the basic prototypical structure of the categories, there are indications that the physicians had greater recall performances, a richer network of knowledge and greater associative strength within their network of knowledge.

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To the memories of

my parents, Edmond and Rita Bordage

and

the founder of the Bureau de pédagogie médicale,
Dr. Gilles Cormier.

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TABLE OF CONTENTS

LIST OF TABLES

TABLE (cont.)

LIST OF FIGURES

"...qui eût plutôt la tête bien faite que bien pleine;"

MONTAIGNE (Essai XXVI, 1580)

"...with a well-made rather than a well-filled head;"

(translated by D.M. Frame, 1948)

CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

How is medical knowledge organized in physicians' long-term memory? Are different structures related to different learning outcomes or clinical performances?

THE PROBLEM

The incentive to study the structure of physicians' memory came from common conclusions reached by investigators of the reasoning process in general and of clinical reasoning in particular. Cast within the information-processing tradition of inquiry, a varied program of research on the psychology of medical reasoning was recently conducted by two groups of investigators: Elstein, Shulman, and Sprafka (1978) and Barrows, Feightner, Neufeld, and Norman (1978). The former group studied the problem-solving characteristics of 24 experienced clinicians (internists) as they solved three diagnostic problems (infectious mononucleosis, regional enteritis, and multiple sclerosis). They found that physicians engaged in a diagnostic reasoning process commonly use a strategy of generating and testing hypothetical solutions to the problem. A small set of hypotheses are generated very early in the clinical encounter based on a very limited amount of data compared to what will eventually be collected. Often the chief complaint is sufficient to establish an initial set of working hypotheses. They summarized

their findings in a four-stage model of diagnostic reasoning:

1. cue acquisition: information is obtained by the clinician through a variety of means, including taking a history, performing a physical examination or administering a battery of tests;

2. hypothesis generation: alternative problem formulations are retrieved from long-term memory;

3. cue interpretation: the data are interpreted in the light of the alternative hypotheses under consideration;

4. hypothesis evaluation: the data are weighted and combined to determine if one of the diagnostic hypotheses already generated can be confirmed; if not, the problem must be recycled, generating new hypotheses and collecting additional data until verification.

While it was initially hypothesized that differences in the reasoning process between excellent and weaker diagnosticians could be accounted for by variations in the strategies they used to solve problems, the observational data showed otherwise. Elstein et al. (1978) concluded: "the differences between experts and weaker problem solvers are more to be found in the repertory of their experiences, organized in long-term memory, than in differences in the planning and problem-solving heuristics employed" (p. 276). Allal's study of the early hypothesis generation process (1973) indicated in particular that problem formulation is primarily a process of direct associative retrieval rather than a strategy-guided activity.

Barrows et al. (1978) reached similar conclusions in their study of the problem-solving characteristics of 22 medical students and 62 physicians. They also showed that the clinical reasoning process is essentially similar between the novice medical student and the experienced practitioner. However, "the one characteristic of the process

which consistently differentiated groups with differing experience was the content of the diagnostic hypotheses" (Norman, Jacoby, Feightner, and Campbell, 1979, p. 214) and, in a broader sense, the organization of their knowledge in memory.

In retrospect, the same kind of general conclusion that DeGroot (1965) reached in his studies of chess players is also true of physicians:

> ...basic, differentiating variables were not to be found in the realm of (macro) operational thinking methods but rather in the scope and the dynamics of the subjects' specific chess memory: the specific, highly differentiated system of experiential links a chess master has and a lesser player has not been able to acquire... If we want better to understand, better to describe systematically, to explain theoretically and to simulate electronically the achievements and thought processes of chess masters, we had better study their perceptual and memory organizational process. (DeGroot and Jongman 1966, p. 2)

THE STRUCTURAL REPRESENTATION OF KNOWLEDGE

Prevailing attempts to describe specifically the structure of knowledge as stored in memory are contained in a number of models, some of which evolved from concepts such as networks and others from set theory (Mayer, 1977). Models derived from networks depict memory as a collection of knowledge units and the multiple associations among them; for example, Collins and Quillian's hierarchies (1969 and 1972); Anderson and Bower's tree diagrams (1973); and Rumelhart, Lindsay, and Norman's directed graphs (1972). Set theoretic models, such as Meyer's two-stage model (1970) and Rips, Shoben, and Smith's semantic distance model (1973; Smith, Shoben, and Rips, 1974) depict memory as being composed of features that belong to sets which in turn belong to larger sets and so on.[1] Most of these models have been applied to the organi-

(1) More elaborate accounts can be found in Posner (1973), Klatzky (1975), Mayer (1977), and Kail and Hagen (1977).

zation of medical knowledge such as Wortman's hierarchies in neurology (1966, 1972, mimeo); Schwartz and Simon's trees with shortness of breath (1971 and 1972); Pauker's networks in internal medicine (1976; Szolovits and Pauker, 1978); and more recently Johnson (1980, in press) and Swanson's networks (1979 a, b; 1980) in pediatric cardiology.

As evidenced by the different types of organizations mentioned by these various researchers, their findings have not led to the elaboration of a decisive model or theory of memory organization in general and much less of physicians in particular. Furthermore, the particular structures reported by these researchers often beg the question of whether they were inevitable given the particular experimental procedures used (for example, the hierarchies given the card-sorting task in Wortman, 1966). These studies have little or no built-in mechanisms for competing hypotheses. Moreover, the underlying frame of thought is one that is strongly grounded in a deterministic and clear-cut view of the world (hierarchies, trees); a view that will be challenged later in the present study. Despite their differing conclusions however, most investigators have one point in common - the importance of categorization as a basic element in the study of the mental organization of knowledge.

CATEGORIZATION

Man's environment is composed of an infinite number of different objects and events. Because of his limited cognitive capacity (Simon, 1947; Miller, 1956; Newell and Simon, 1972), it is imperative for man to deal with classes or categories of occurences rather than with the individual objects or incidents. Categorizing, as stated by Bruner, Goodnow, and Austin (1956), "serves to cut down the diversity of objects

and events that must be dealt with uniquely by an organism of limited capacity and it makes possible the sorting of functionally significant groupings in the world" (p. 245). Simply defined, a category consists of a number of different objects or events that, for some practical reason, are considered as equivalent.

Categories can be conceived of in two ways as demonstrated in the following two scenarios. Imagine two professors of medicine responsible for teaching a medical student about the disorders called anemia. The first professor elaborates a definition by establishing one or more criterial features of anemia; for example, "a condition in which the number of red blood cells per cubic mm, the amount of hemoglobin in 100 ml of blood, and the volume of packed red blood cells per 100 ml of blood are less than normal" (from Stedman, 1976, p. 68). From this criterion, the professor draws the entire list of anemias and presents it to the student. Each anemia shares the criterial features and has full degree of membership in the category. The second professor, on the other hand, has the student collect a number of examples of anemia: pernicious a., spherocytosis, iron deficiency a., thalassemias, hypovolemia, and so on. At some point, the student recognizes, or is told, the commonality of these different instances and forms a category called anemia. In the category, some instances are better examples or clearer cases of anemia than others and have come to represent the category as a whole. In the first scenario, the striking feature of the category is its predetermined criterion or rule for membership. In the latter scenario, the striking feature of the category is the key examples that represent the category as a whole. While both notions of category are logical, the logic is of a different nature. In the first instance,

anemia is derived from the traditional Aristotelean laws of logic; in the second instance, it is derived from the psychological representation of the category in the student's head.

Many traditions of thought in the Western world imply that categories are rule-defined structures derived from a criterion and expressed within definite boundaries inside which all items have equal membership. Two problems arise from this notion. First, some categories do not possess a simple set of criterial attributes for all its members and, second, it is often unclear as to whether some members, although sharing a criterion, do indeed belong to a given category. For example, one of the criterial attributes of neoplastic disorders is "rapid proliferation of growth" (Stedman 1976). Counter examples of true neoplastic disorders that are not characterized by rapid growth immediately come to mind such as epitheliomas of the skin or the uterine cervix. As for unclear membership, while hypovolemia (a deficit in blood volume) complies with the definition of anemia, few physicians would categorize it as such. It is more a state of shock than an anemia. Wittgenstein (1953) further exemplified the problem of a simple criterial attribute when he was unable to identify one criterion for the everyday concept of games. He then argued that:

> the referents of a word need not have common elements in order for the word to be understood and used in the normal functioning of language...rather, a family resemblance might be what links the various referents of a word. A family resemblance relationship consists of a set of items of the form AB, BC, CD, and DE. That is, each item has at least one, and probably several, elements in common with one or more other items, but no, or few elements are common to all items. (reported in Rosch and Mervis, 1975, p. 574)

Rosch and co-workers (1973-78), as well as other cognitive psychologists such as Rips, Shoben, and Smith (1973) and Tversky (1977), empirically demonstrated the Wittgenstenian insight. For example, Rosch demonstrated for categories of colors that they are "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" (Rosch, 1975c, p. 193). For example, a Retriever or a German Shepherd is a very "doggy" dog, while a Pekinese is a less "doggy" dog (Rosch and Mervis 1975). From our previous example, some anemias should be represented in the student's memory as clearer cases of anemia than others, such as pernicious anemia as opposed to spherocytosis. Rosch (1973) concludes:

> The psychological reality of internal structure implies that the abstract, 'formal' definition of categories (in terms of genus and differentia, or in terms of an intersection of criterial attributes) does not fully correspond to the category as a psychological 'unit'. (p. 141)

Most germane to the present study on memory organization is Rosch's work on the internal structure of categories, the prototypes. She has shown that subjects overwhelmingly agree in their judgments about the prototypicality of items from a variety of domains.[1]

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(1) Including: noun concepts (Rosch and Mervis, 1975; Rosch, 1973, 1975c; Rosch et al., 1976a), colors (Rosch, 1973, 1975a, 1975b), line patterns (Rosch, 1975c), numbers and letters (Rosch et al., 1976a; Rosch et al., 1976b) drawings of objects (Rosch, 1975c), line drawings (Rosch, 1975c; Rosch et al, 1976a), forms (Rosch, 1973), shapes of objects (Rosch et al., 1976a), pictures of objects (Rosch, 1975a; Rosch et al, 1976a), and dot patterns and stick figures (Rosch, et al., 1976b).

She has also shown that the prototypicality of items within a category affects most of the variables used as measures for the study of memory.[1] For example, the most prototypical items in a category are recalled first in free-recall tasks. They are retrieved faster from long-term memory than the less prototypical items. And, they are the instances in a category with the greatest number of links with the other members of the category.[2]

It is the contention of the present investigator, from his personal experience and that of colleagues, that physicians structure most if not all of their knowledge of medical disorders according to key cases or typical presentations rather than by lists of criterial features. For example, it is quite common to hear physicians say during clinical rounds: "This patient reminds me of such and such a disorder." Seldom do physicians go through a list of criterial features to determine category membership. The question then arises, Is the concept of prototypes, as developed by Rosch, applicable to the physicians' mental categorization of medical disorders?

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(1) Including: reaction time (Rosch, 1973, Rosch, et al. 1976b), rate of learning (Rosch, 1973, Rosch, et al., 1976b), item output (Rosch, 1975c, Rosch, et al., 1976b), priming (Rosch, 1975c, 1975b, Rosch, et al., 1976b), motor movements (Rosch et al., 1976a), and logic of natural language (Rosch, 1975a, 1976).

(2) Rosch's conception of categorization is compatible with the work of a number of other investigators in the field (Smith, 1978). For example, the notion of a prototype is related to the Gestalt notion of ideal types which act as anchor points for perception and conception (Wertheimer, 1938 and 1945). Prototypicality is also related to Franks and Bransford's base patterns (1971) as well as Tversky's set theoretic notion of similarity (1977; Tversky and Gati 1978). The notions of prototypes and fuzzy sets are also related. While Rosch's prototypes emphasizes the central tendency of categories, Zadeh (1965) and Lakoff's (1972) fuzzy sets (Oden, 1977; McCloskey and Glucksberg, 1978; Horvath et al., 1980) emphasize the boundaries.

THE INTEREST

Most curricula in North American medical schools are discipline-centered. The material to be taught and learned is organized according to subject-matter areas in the basic sciences and in clinical medicine, including anatomy, biochemistry, pharmacology, pathology, surgery, pediatrics, and so on. The emphasis for the teachers is to transmit to the learners an up-to-date body of information corresponding to the state of the art in their disciplines and consequently for the learners to acquire as much of the information as possible. Most often, the subject-matter information is organized in a pre-determined, criterial fashion. For example, most textbooks and classroom presentations follow this pattern: Definition-Nomenclature-Classification (listings of disorders)-Characteristics.

As pointed out by Barrows and Tamblyn (1980), two problems arise from this educational situation. First, the acquisition of knowledge, as large as it may be, is not synonymous with the ability to apply that knowledge to solve problems (Wingard and Williamson, 1973). And second,

> In subject-based learning the information is not readily recalled or reinforced by work with patients, since it is learned in association with an organized subject. Generations of students in conventional curricula have expressed the desire to repeat basic science courses when they enter their clinical years, testimony to their frustration over the inability to recall subject-based information from earlier years. (p. 11)

This latter problem clearly suggests that the way the information is organized in the pre-clinical medical student's long-term memory may not be best suited for solving problems. Recent emphasis on problem-based learning (Ways et al., 1973; Barrows and Mitchell, 1975; Barrows and Tamblyn, 1980) and on the early introduction of problem-solving expe-

riences in the undergraduate medical curriculum (Bordage, 1979; Elstein, Sprafka, and Bordage, 1979) were aimed at bridging the gap between the acquisition and the application of the knowledge acquired by the medical students. If the curriculum planners, and consequently the teachers and the students, are to facilitate the transfer of knowledge to the practice of medicine, then it is imperative to gain as clear a notion as possible of the way knowledge is organized in the physician's memory for the purposes of identifying and managing people's health problems. The two types of memory structures reviewed, criterial and prototypical, are quite different in nature and teaching that fosters one or the other may help or hinder the use of knowledge in clinical practice. In particular, if during the undergraduate years the medical students are led to store their knowledge in a traditional criterial fashion only to find out later that the reality of medical practice is such that a prototypical organization is more efficient, the curriculum planner will have failed to maximize the efficiency of the program. While a criterial structure may be best suited to classify the accumulated knowledge in a discipline, recent curricular developments and the perceptions of many physicians suggest that a prototypical structure may be best suited for the retrieval of knowledge in a problem-solving situation. The difference for the clinician is between lists of criterial features and classifications on the one hand, and key problems or presentations on the other as the organizing principle for the categorization of medical disorders.

THE STUDY

The purpose of the present study is to determine whether the

concept of prototypes is "applicable" to the mental categorization of medical disorders as expressed by medical students and experienced clinicians. Applicability, as in Rosch's studies, refers to two issues: (1) Can physicians make meaningful judgments about the degree to which various disorders are prototypical members of categories (best examples, clear cases), and (2) can a case be made that a prototypical structure affects the processing of the categories?

The design of the study will be presented and discussed in the next chapter after which follows a series of four experiments that provide a logical and converging sequence of evidence concerning the internal structure of selected categories of medical disorders. The characteristics of each experiment and the results obtained are reported in Chapters III, IV, V and VI. Finally, and throughout the study, the influence of diagnostic experience on memory structures will be analyzed by comparing two samples of subjects with contrasting levels of diagnostic experience.

SUMMARY

The present study on the cognitive structure of medical knowledge was the result of a three-stage focusing process. First, memory was identified as a critical element in the problem-solving process of physicians. Recent studies (Elstein et al., 1978; Barrows et al., 1978) have shown that the differentiating factor between excellent and weaker diagnosticians is more likely to be found in variations in the content and organization of their knowledge stored in long-term memory than in differences in their thinking methods. Second, although existing research was yet unclear about a specific theory or model of the cognitive

structure of knowledge in long-term memory, most investigators agree on the importance of categorization as a critical issue in the study of human memory. And third, it was hypothesized, based on Rosch's work on categorization, that physicians structure their knowledge of medical disorders into prototypes, the clearest cases or best examples, with non-prototypical instances tending toward an order from better to poorer examples.

The object of the present study is to determine whether the concept of prototypes is applicable to the mental categorization of medical disorders. Four experiments were designed and conducted to provide a logical and converging sequence of evidence concerning the internal structure of selected medical categories.

CHAPTER II

OVERVIEW OF THE STUDY

The purpose of the study is twofold: (1) to experimentally test certain hypotheses concerning the internal structure of selected categories of medical disorders as they are represented in the physicians' long-term memory, and (2) to describe the influence of diagnostic experience on those structures. The present chapter contains an outline of the four experiments comprising the study as well as introductions to the samples, the reliability of the measures, and the pretesting of the experimental materials.

THE STUDY

Is the concept of prototypes, as developed by Rosch, applicable to the internal structure of medical categories? To answer systematically this kind of question with regard to various domains of categories, Rosch (1975c) has successfully used a research strategy composed of converging experiments. Each experiment, although aimed at the same object, helps to bring a particular facet of the object into focus. Insights derived from the individual experiments are pooled and are most likely to yield an overall representation of the object. Accordingly, four experiments were designed and conducted to jointly provide a characterization of the internal structure of selected categories of medical disorders.

As stated in the preceding chapter, the distinctiveness of categories can be achieved in two ways: by means of formal, necessary and sufficient criteria for category membership, or by conceiving of each category in terms of its clear cases. The arguments in favor of the latter view come from the operational definition of two concepts - prototypes and family resemblance. The level of prototypicality of an item is derived from people's perception of how good an example various members are of a category (Rosch, 1973, 1978). The degree of agreement among the judgments is an indication of how applicable the concept of prototypicality is.[1] Prototypes, like categories themselves, develop through the maximization of family resemblance. Rosch and Mervis have shown (1975; Rosch, 1978) that "members of a category come to be viewed as prototypical of the category as a whole in proportion to the extent to which they bear a family resemblance to (have attributes which overlap those of) other members of the category" (Rosch and Mervis, 1975, p. 575). Rosch and Mervis (1975) have shown for categories of concrete nouns that the more prototypical of a category a member is rated, the more attributes it has in common with other members of that category.

Three experiments were designed to determine the applicability of these two concepts to the categorization of selected medical disorders. In the first experiment, Category norms, a description of the content of 14 preselected categories was obtained from two samples of clinicians who had contrasting levels of diagnostic experience, namely pre-clinical medical students and experienced general practitioners. The second

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(1) The reliability of such judgments is high even under changes of instructions and items (Rips et al. 1973; Rosch, 1975b, 1975c, 1978; Rosch and Mervis, 1975).

experiment, Prototypicality ratings, directly addressed the issue of prototypes: do subjects agree concerning which disorders in a category are the most prototypical? The third experiment, Family resemblance, was a test of two hypotheses concerning the family resemblance relationships in a category: (1) that each disorder in a category has at least one attribute (for example, symptom, sign, pathophysiological characteristic) in common with one or more other disorders, but none, or few attributes are common to all disorders; and (2) that the most prototypical disorders in a category are those with the most attributes in common with other members of the category. The former of these two hypotheses was also a direct test of the competing deterministic view of categorization. The result pooled from these experiments will be used to build an argument for, or against, a prototypical structure of categories of medical disorders.

Assuming that the prototypicality was reliably rated and was correlated with category structure, the next issue investigated was whether or not the prototypicality of items in a category affected the processing of the category. If categories are viewed in terms of their clear cases, then instances in a category are not all equivalent. Some have a greater degree of membership than others. It could then be expected that the degree of membership of an item might well affect the time needed for subjects to judge that the member belonged to the category. A fourth experiment, Response time, was designed to test the hypothesis that the degree of prototypicality predicted response time to verify category membership statements.

Thus, the applicability of the notions of prototypes and family resemblance to categories of medical disorders was not to be based on

one test but on the results pooled from four different, but converging, experiments. If the internal structure of medical categories in the subjects' long-term memories was a prototypical one, then the results from all, if not most, experiments should point toward that conclusion.

In order to cast the present study in its proper perspective, it is important to delimit its scope clearly. Rosch (1975c) is careful to indicate that "the research was designed to investigate the nature (the structure and content) of cognitive representations of semantic categories, not the dynamic processes 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" (p. 194). Study of the formation and actual use of categories is seen as a separate stage of investigation and consecutive to the results obtained in these initial studies on internal structure. Therefore, and because of combined theoretical and methodological shortcomings, the initial broad questions about memory organization and its possible effect on clinical performance (for example, in making a diagnosis or choosing a treatment) had to be fractionated into smaller, more manageable ones.

For each experiment reported in the next four chapters, a common sequence of presentation is used. First, the purpose of the experiment and the specific hypothesis(es) to be tested are stated. Then, the subjects are described and the stimulus materials, the instructions, and the experimental procedures are presented. All four experiments were conducted in French. Finally, the data analysis procedures are stated and the results are presented and discussed.

SAMPLES

Two samples, one composed of 100 pre-clinical medical students and another one of 77 experienced physicians, participated in the study. These two samples were chosen because they represented contrasting levels of diagnostic skills with the novice diagnostician represented by the pre-clinical students as opposed to the expert diagnostician represented by the experienced physicians. It can be hypothesized that prototypes become more clearly defined (Rosch, 1973; Rosch et al., 1976a) and that the categories contain a richer (Elstein, Loupe, and Erdmann, 1971; Larkin, et al., 1980), more closely woven network of information (Shavelson, 1972) with increasing experience. It can also be expected that the more experienced subjects would have quicker access to the information in a category than the novices (Rosch, 1973).

A pre-clinical medical student was defined within the context of a traditional medical curriculum as a medical student who has completed the basic-sciences part of the curriculum, including the various system pathologies, and who is at the beginning or about to begin the in-hospital training or clerkships. In a five-year program (including internship), this corresponds to the period covering the latter part of the third year and the beginning of the fourth. At that particular time, the student has a book-learning knowledge of medicine, with limited diagnostic experience, and is about to use and complement his knowledge with a clinical training program. Two criteria were used to guide the definition of a novice diagnostician. First, in order for the experimental tasks to be meaningful, it was necessary that the novices have already acquired sufficient medical knowledge to be able to deal with the range of medical nomenclature presented. Second, to explore devel-

opmental transformations, it was imperative that the novice had not already acquired a level of experience in the practice of medicine that would overlap with that of an experienced diagnostician.

The student population of interest can be found in most American medical schools. However, because of limited resources, one such student subpopulation was preselected for the study - that of the French speaking pre-clinical medical students at Laval University Medical School in Quebec City (Canada).

All of the 152 third-year medical students at Laval met the sampling criteria. They were all solicited by letter to participate in one of the four experiments. Participation was voluntary and subjects were not paid. The experimental sessions were held during off-hours in the early evening. Overall, 100 students participated (66%). The remaining 52 students did not volunteer even after receiving a follow-up letter requesting their participation. No further steps were taken to recover the non-participants nor to find out directly why they did not participate. To determine whether the non-participants differed systematically from the participants, their respective GPA scores were compared. This score was believed to be correlated substantially with the dependent variables in the study since both were measures of medical knowledge. The mean GPA score of the participants was equal to 4.22 ($s = .38$) as opposed to 4.27 for the non-participants ($s = .36$). The two sets of scores did not differ significantly ($\alpha = .1$; $t(150) = .78$, $p = .22$). This finding lends support to the argument that the results of the study may be generalized to the entire class of third-year medical students at Laval.

The real population of interest, however, extends beyond the pre-clinical medical students enrolled at Laval and would include, using a Cornfield-Tukey bridge argument, all comparable pre-clinical medical students. To be comparable, a student should share the following individual and institutional characteristics of the Laval students. The average age of the Laval participant is 23.8 years (range: 21 - 32). The majority of the participants are male (66%) and all are French-speaking, born and raised in the Province of Quebec, Canada. Most of the students at Laval are bilingual (all read English) and about half of the textbooks are in English. The courses are organized according to a traditional discipline-oriented curriculum comparable to most North American undergraduate medical programs. The first two and a half years are composed of basic sciences with little clinical exposure, followed by three months of introduction to clinical methods, 14 months of clerkships and 12 months of internships. A brief description of the basic-sciences portion of the curriculum is presented in Appendix A. The students participated in the study during the first month of their three months of introduction to clinical methods.

An experienced physician can be defined in a number of ways ranging all the way from a group of general internists to some specialists such as endocrinologists or thoracic surgeons. Because of the prevailing trend of many medical schools to emphasize family practice in their curriculum, that very population of general practitioners was targeted. An experienced general practitioner was defined as a physician who (1) does not have any specialty certification, except that from the College of Family Physicians, (2) has been in active practice for at least one year, and (3) is seeing patients on a regular weekly basis.

The samples of physicians participating in the study came from two sources. Physicians participating in Experiments 1 and 3 were selected from the pool of physicians belonging to the greater Quebec City chapter of the Quebec Federation of General Practitioners (including urban and rural practitioners). The ones participating in Experiments 2 and 4 were solicited while attending one of two continuing medical education conferences for general practitioners, one on emergencies, the other on ophthalmology.

From a total of 94 physicians solicited, 77 agreed to participate (82%). All were solicited directly or by telephone. The experimental sessions were held either during off-hours in their own office settings (Experiments 1 and 3) or between two presentations during the conferences. Participation was anonymous and voluntary and subjects were not paid for their time and effort. No efforts were made to recover the non-participants nor to ascertain why they refused to participate.

Here also, the real population of interest extends beyond the general practitioners in the Province of Quebec and would include all comparable experienced physicians. To be comparable, a physician should share the characteristics of the Quebec physicians presented in Table 1. All the physicians graduated from one of the three French-speaking medical schools in the Province of Quebec, except one coming from the University of Toronto. The great majority were Laval graduates (88%); 5% graduated from Sherbrooke and 7% from Montréal. All practiced in predominantly French-speaking communities.

Table 1. Selected characteristics of the physician sample.

n = 77
Average age: 33.9 (range: 25 to 56)
Sex: 78% men, 22% women
Average years in practice: 8.5 (range: 2 to 28)
Average number of patients seen per week: 104 (range: 15 to 200)
Certified family physicians: 17%
Type of practice: - Solo: 22% - Group: 78%
- Full-time: 89% - Part-time: 11%
- Hospital affiliation: 59%
- University affiliation: 16%
- Urban: 73% - Rural: 27%

The size of the samples and the distribution of the subjects among the four experiments were based on sample sizes used in previous studies of this kind and on the availability of the subjects locally. Based on previous investigations, it was decided to allocate more subjects to the first and third experiments (Battig and Montague, 1969; Hunt and Hodge, 1971; Rosch and Mervis, 1975; Rosch et al., 1976a) and fewer to the second and fourth experiments (Rosch, 1973, 1975c; Rosch and Mervis, 1975; Rips, Shoben, and Smith, 1973). Accordingly, a minimum of 20 subjects were sought for the first and third experiments (that is, 20 and 10 subjects for each set of items in each experiment respectively) and 12 subjects for the second and fourth experiments (that is, 12 and 6 subjects for each set of items in each experiment respectively). Consequently, the 152 students were randomly divided into four groups in proportion with the minimum number of subjects

needed for each experiment. As for the physicians, their participation was solicited until the minimum sample size had been reached for each experiment. The distribution of subjects for the four experiments is presented in Table 2.

Table 2. Distribution of subjects for the four experiments.

	1-Category norms	2- Prototypicality rating	3-Family resemblance	4-Response time	Total
Minimum number of subjects sought:	20	12	20	12	
Number of students:					
solicited	60	16	60	16	152
participated	40	13	31	14	100
Number of physicians:					
solicited	30	19	30	15	94
participated	21	19	23	14	77
Total participation:	61	32	54	28	177

RELIABILITY

The experiments in the present study follow the same methodology that Rosch and her co-workers used in their studies. This methodology is based on established paradigms of investigation in the study of human memory such as, free recall (Murdock, 1976; Graesser II and Mandler, 1978), category membership ratings (Collins and Quillian, 1969; Lakoff, 1972; Smith, Shoben, and Rips, 1974), and reaction times (Collins and Quillian, 1969; Landauer and Freedman, 1968; Meyer, 1970). The various measures used in the four experiments have a well documented history of

high construct validity and high reliability (for example, Garskoff and Houston, 1963; Johnson, 1969; Battig and Montague, 1969; Hunt and Hodge, 1971; Rips, Shoben, and Smith, 1973; Rosch, 1974, 1975c). Appropriate measures of reliability for the variables used in this study were computed and are presented for each experiment.

PRETESTING

Each one of the four experiments was a nearly exact replication of Rosch's experiments on categorization of colors and real-world objects (1973; Rosch and Mervis, 1975). Because the subjects are French-speaking, each instruction set was translated from English to French. Slight variations existed between the two versions and were due to the fact that the English version was in conversation-like format (for example; For each page you'll have two minutes to write down all of the attributes of that object that you can think of), while the French version was more explicit and direct (for example; Step 1 - Read the category name; Step 2 - List all the attributes that you can think of; Step 3 - You will have two minutes per category and the experimenter will tell you when to turn to the next page). Both versions conveyed the same meaning.

The experimental materials were pretested with a group of five physicians. Upon completion of the four experiments, the instructions and the tasks were critically reviewed as to their clarity, practicability, and meaningfulness. Results were also compiled and analysed. In light of the comments made and the results obtained, few if any changes were made for any one of the four experiments.

SUMMARY

Based on Rosch's work on categorization, the purpose of the present study is twofold: (1) to test experimentally four hypotheses concerning the internal structure of selected categories of medical disorders, and (2) to describe the influence of diagnostic experience on memory structures. Four experiments were designed to provide a logical and converging sequence of evidence:

1-	Category norms:	Which disorders belong to each category?
2-	Prototypicality ratings:	Do subjects agree about which medical disorders are the most prototypical members of a given category and which are less prototypical?
3-	Family resemblance:	Do individual disorders in a category have at least one attribute in common with one or more other disorders, but none, or few, attributes common to all disorders?
		Do the more prototypical disorders in a category have more attributes in common with the other members than the less prototypical ones?
4-	Response time:	Are the responses to category membership statements faster for the disorders that have been rated more prototypical than for the less prototypical ones?

A description of the two samples was given as well as the selection procedure used. The reliability of the various measures used was documented and the experimental materials were pretested with five physicians.

CHAPTER III

EXPERIMENT - 1: CATEGORY NORMS

PURPOSE

The purpose of the first experiment, Category norms, was to obtain a description of the content of various categories of medical disorders as expressed by pre-clinical medical students and experienced physicians. Comparative measures of the content among category types and between subject types were compiled. The lists of disorders obtained served as the taxonomic norm for the following experiments on internal structure.

SUBJECTS

Of the 152 students available, 60 were randomly selected to participate in this experiment, of whom 42 accepted (70%). Of the 30 physicians solicited, 21 accepted (70%).

STIMULI

Rosch studied the structure of a variety of categories selected from different levels of abstraction (inclusiveness). She showed that there is a basic level of abstraction at which objects were most naturally divided into categories. However, in her initial experiments on the internal structure of categories (1973; 1975c), she started by selecting broad and widely accepted category names as stimulus materials,

without any prejudice as to the level of abstraction. A similar selection procedure was applied for the present study. A total of 14 category names were chosen based on three different taxonomies of medical disorders, namely, the classification of medical disorders according to (1) organ systems, (2) pathophysiological processes, and (3) principal clinical manifestations.[1] Since the population of interest was general practitioners, the organ systems names, eight altogether, were drawn from a widely accepted classification of medical problems in family practice, the coded classification of disease of the Royal College of General Practitioners (Marshland, Wood, and Mayo, 1976). The remaining six category names were selected by the experimenter according to standard medical references (Thorn et al., 1977; Robbins and Cotran, 1979; and Prior and Silberstein, 1973). See Table 3 for the entire list. The intent was not to obtain a range of categories that would cut across different levels of abstraction but, rather, to initiate the study at an apparently high level of inclusiveness and to sample different types of taxonomies. Most of all, it was important to obtain normative data from the same population of subjects on which future experiments were to be done.

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(1) These are the three most common taxonomies of medical disorders used in such medical textbooks as Harrison's Principles of Internal Medicine (Thorn et al., 1977) or in such standard classification codes as the International Classification of Health Problems in Primary Care.

TABLE 3 Stimuli for category membership experiment.

ORGAN SYSTEMS-RELATED DISORDERS:	PATHOPHYSIOLOGY-RELATED DISORDERS:
1. Respiratory disorders	9. Inflammatory disorders
2. Cardiovascular disorders	10. Infectious disorders
3. Genitourinary disorders	11. Neoplastic disorders
4. Gastrointestinal disorders	
5. Endocrine disorders	SYMPTOM-RELATED DISORDERS:
6. Musculoskeletal disorders	12. Dyspnea
7. Neurological disorders	13. Abdominal pain
8. Hematological disorders	14. Joint pain

INSTRUCTIONS

Subjects were asked to list the disorders that they felt belonged to each of the 14 categories. The experiment was conducted in French. A modified version of Battig and Montague's instruction set (1969) was used[1]:

There are 14 pages in this booklet. At the top of each page you will be given the name of a category usually found in medicine. For each name, please proceed as follows:

1. Read the name of the category.

2. Write down legibly the name of as many disorders included in that category as you can think of (diseases, pathologies, problems). You will have 2 minutes to write down these items using one line per item. Do not pay any attention to misspellings; strike out a mistake rather than erase it.

3. When you hear the signal indicating the end of the two-minute period, stop writing and turn immediately to the next page of the booklet.

4. Repeat the preceding steps for each one of the 14 categories.

(1) The actual French instructions are available upon request.

Here is an example:

Category: Furniture

chair	rocking chair	trash can
couch	coffee table	paintings
table	shelves	telephone
desk	piano	ash tray

In the example, the subject listed a certain number of items belonging to the proposed category. These answers are neither right nor wrong. They are the subject's spontaneous expression. He could have listed more or fewer items depending on how many came to his mind at the time.

Do not stop to think why you may answer in a certain way. do not pay any attention to what others may think. Write down your answers as they spontaneously come to your mind.

PROCEDURE

Each one of the 14 category names was printed at the top of a page with the pages assembled into a booklet along with a short demographic questionnaire and a set of instructions. Each subject received a booklet, answered the questionnaire, and read the instructions. The experimenter then answered any questions to clarify the procedure; however, questions were rarely asked. Each subject then completed the 14 categories with the two-minute pacing being signaled by the experimenter in front of the room. Subjects were tested in groups ranging in size from two to 18 persons. Experimental sessions lasted between 40 and 45 minutes each.

To minimize any sequential effects on the responses, five different random sequences of the categories were used. Each sequence was

thus completed by approximately 12 subjects and each subject completed all 14 categories.

ANALYSIS AND RESULTS

The criteria used to tabulate the responses were an extended version of the ones used by Hunt and Hodge (1971):

1- Misspellings were recorded under the correct spelling.

2- Singular and plural items were treated as singular.

3- Adjective and noun grammatical forms were treated as nouns (for example, infectious and infection).

4- Responses which included the category name (for example, wound infections, gastrointestinal bleeding) were recorded without the category name (wound, bleeding).

5- Abbreviations judged to be clinically acceptable were recorded as such (for example, pO_2, Hb); others were written out in full (for example, CA prostate: cancer of the prostate).

6- Synonyms were treated alike as proposed in Dorland or Stedman's medical dictionaries, and were recorded under the most common designation (for example, Basedow's disease, Graves' disease, and toxic goiter).

7- If it seemed likely that the identity of an item would be lost by application of the preceding criteria, the original form of the item was retained (for example, pernicious anemia and macrocytic anemia were recorded separately).

8- Repetitions were recorded only once.

Results were tabulated separately for each category and for each sample (students and physicians) and included:

1- A list of all separate responses presented in a decreasing order of frequency.

2- For each response, five measures were computed:

TF Total frequency of occurence of that response for the entire sample.

MR Mean rank position of response outputs in the sequence of responses given by each subject.

FMIN Earliest (minimum) output rank in any one given sequence for the whole sample.

FMAX Latest (maximum) output rank in any one given sequence for the whole sample.

F1 Number of times each response was mentioned first in the response sequence.

3- The number of illegible responses for the whole sample.

A total of some 10,600 responses were tabulated by the experimenter. Approximately 15 percent of these responses were drawn from two randomly selected categories (Gastrointestinal and Joint pain) for each sample and were independently retabulated by another physician. The second rater agreed with an average of 98.6% of the experimenter's tabulations for each category (range: 97.5 to 99.4). There were no systematic errors of interpretation in the disagreements. Most discrepancies were due to the omission of a response by one of the two raters. New items were rarely added by the reviewer (5 items altogether). Synonyms were rarely a problem (4 instances altogether).

Of the five random sequences of category names used, only one item in the sequence received a consistently different response pattern depending on its position in the sequence, namely Infectious disorders. In the fifth sequence, the category name "Infectious disorders" appeared in the sixth position; whereas in the four other sequences, it appeared either in the 10th or 14th position. In the one case where it appeared earlier in the sequence, subjects tended to list more organ-related

disorders (for example, prostatitis, gastritis, otitis) than in the other cases where they listed more diverse and general responses (for example, pneumonia, T.B., cellulitis). This bias was noted in less than one fifth of the responses for that category, and it was not judged to be of sufficient magnitude to alter the tabulation procedure. Consequently, the responses for this category were compiled as they originally appeared.

Overall, each student listed an average of 11.5 items per category as opposed to 13.1 for the physicians (repeated measures ANOVA: $F(1,61) = 6.93$, $p < .01$; interaction between subject types and categories was significant: $F(13,793) = 4.15$, $p < .001$). See Table 4. The basic descriptive data for each category is presented in Appendix B for each response given five times or more in either of the two samples.[1]

The purpose of this first experiment was to establish separate category membership norms for the students and the physicians. The similarities and the differences in the responses between the two samples were analyzed both quantitatively and qualitatively.

There was a higher level of commonality in the responses among the physicians than among the students. The Wilcoxon matched-pairs signed-ranks test between the students and the physicians, calculated over the 14 categories, was significant ($T = 12.5$, $p < .01$) with a mean agreement of 78.2% for the physicians as opposed to 70.2% for the students (see Table 5). For instance, there were one-third more items that were shared by 10 or more of the subjects in the physician group

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(1) The entire set of results is available upon request. A typical tabulation for one entire category is presented as an example in Appendix C.

TABLE 4. Mean number of responses given for each category.

Category	Students		Physicians	
Respiratory	13.3	(3.3)+	14.5	(4.3)
Cardiovascular	14.5	(3.2)	13.8	(3.1)
Genitourinary	11.9	(4.5)	14.8	(4.5)
Gastrointestinal	12.4	(3.0)	15.7	(3.8)
Endocrine	9.5	(2.4)	10.3	(2.9)
Musculoskeletal	10.5	(3.2)	13.5	(4.7)
Neurological	8.3	(3.2)	10.7	(3.6)
Hematological	9.1	(2.7)	9.0	(2.6)
Infectious	14.6	(4.0)	18.9	(4.2)
Neoplastic	11.6	(4.7)	13.1	(3.6)
Inflammatory	10.8	(4.9)	10.2	(4.4)
Dyspnea	9.6	(2.6)	13.0	(3.2)
Abdominal pain	11.4	(3.1)	15.7	(2.9)
Joint pain	9.9	(3.4)	10.3	(2.5)

+ Standard deviations in parentheses.

TABLE 5. Percentage of subjects listing a common disorder for the most frequently mentioned item in each category (n = 21 in both samples).

CATEGORY	STUDENTS	PHYSICIANS
1. Respiratory	95	86
2. Cardiovascular	100	86
3. Genitourinary	60	81
4. Gastrointestinal	71	67
5. Endocrine	95	100
6. Musculoskeletal	71	81
7. Neurological	62	81
8. Hematological	57	57
Mean 1-8:	76.4	79.9
9. Infectious	62	86
10. Neoplastic	48	57
11. Inflammatory	43	71
Mean 9-11:	51	71.3
12. Dyspnea	76	76
13. Abdominal pain	76	90
14. Joint pain	67	76
Mean 12-14:	73	80.7
Mean total:	70.2	78.2

(that is, physicians giving the same response) than in the student group, 77 versus 49 items, and almost twice as many at the level of 15 or more items in common, 25 versus 13 (see Tables 6 and 7).[1] The higher level of commonality among the physicians was also noticeable for the most frequently mentioned item in each category.

In order to assess the level of similarity in the pattern of response frequencies between the students and the physicians, Pearson product-moment correlation coefficients were computed between the two sets of TFs for all responses given five times or more in either of the two samples. The correlations varied between .14 and .80 with a median of .55 (see Table 8). These correlations, compared to similar measures computed for categories of common objects where the median correlation[2] was .96 (Battig and Montague, (1969), suggest that the relative emphasis given to each item in a category may be different in the two subject groups (for example, while bronchiectasis was mentioned by 13 physicians, only six students mentioned it; and, vice versa, only one physi-

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(1) Because the uneven sample sizes (42 versus 21) would have complicated data analysis, quantitative analysis was performed on results from samples of equal sizes (n= 21), namely, all of the 21 physicians and 21 randomly selected students out of the 42 that participated. To verify whether the non-selected students differed systematically from the randomly selected ones, their respective GPA scores as well as their mean total frequencies of response (TF) were compared. Neither measures varied significantly (α= .1) between the two groups: the mean GPA scores were respectively 4.19 (s= .40) and 4.29 (s= .35) (t(40)= .87, p= .19), and the mean frequencies were respectively 11.7 (s= 2.1) and 11.3 (s= 2.3) (t(40)= .59, p= .28). Furthermore, the nature and sequence of the individual disorders listed in each category was practically the same for the selected and non-selected students.

(2) Correlations were computed between the frequencies for University of Maryland (n= 276) and University of Illinois (n= 172) samples of introductory psychology students.

TABLE 6. Item frequency and agreement for the 14 categories (students; n = 21).

CATEGORY	Number of subjects agreeing																				Total number of different items per category
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
1. Respiratory		1	1		1				2	1		2		4	4		2	6	6	13	31	74
2. Cardiovascular	1	1								1	1		4	2	6	3	4	4	10	11	39	87
3. Genitourinary										3		3		1	2	2	1	4	8	22	59	105
4. Gastrointestinal							1		1			2		2	3	1	6	5	13	13	56	103
5. Endocrine		1		2				3						2			3	4	3	7	30	55
6. Musculoskeletal							1			1	1	1		1		4	1	4	9	13	58	94
7. Neurological									1				1	1		2	3	2	7	15	53	85
8. Hematological										1			3	3	2	3	5	1	6	4	37	65
																				Mean 1-8		83.5
9. Infectious									1	2			1	3	2	2	6	6	7	32	68	150
10. Neoplastic												1			4	3	5	7	14	19	70	123
11. Inflammatory													1	3	2	3	3	7	12	16	52	99
																				Mean 9-11		117.3
12. Dyspnea						1	1				1		3		1	2	3	2	2	20	41	77
13. Abdominal pain						1				1	1		1	2		6	3	2	9	20	43	89
14. Joint pain								1	1	1		2	2	1	1	2	2	3	4	12	46	78
																				Mean 12-14		81.3
																				Mean total		90.3

TABLE 7. Item frequency and agreement for the 14 categories (physicians; n = 21).

CATEGORY	Number of subjects agreeing																				Total number of different items per category
	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	
1. Respiratory				1	1	1		2		1	1		1	2	5	5	3	4	5	15	37	84
2. Cardiovascular				1	1					1	1	1	1	3	1	5	7	4	9	13	46	94
3. Genitourinary					1	1	1	1				1		2	4	2	5	7	7	26	58	116
4. Gastrointestinal								1	2	2	1	4	1	4	3	3	4	3	10	16	40	94
5. Endocrine	1			2						1	1			1	2	2	4	3	8	9	26	60
6. Musculoskeletal					1	1	1				1		2	1	1	3	4	5	8	17	75	120
7. Neurological					1					1		1		2	3	2	2	3	8	14	63	100
8. Hematological										3	1		1		1		3	4	11	14	33	71
																			Mean 1-8			92.4
9. Infectious				1	1		1			2	4		2	2	6	3	6	5	9	19	69	130
10. Neoplastic										1		2		1	3	5	7	8	13	15	49	104
11. Inflammatory							1	1		1					1	2	4	3	8	20	58	99
																			Mean 9-11			111
12. Dyspnea						1	1		3			2		1	3	2	3	4	9	20	45	94
13. Abdominal pain			1		1	1			3			1	2	1	3	4	5	6	14	12	40	94
14. Joint pain						1				1	1	2		4	1	3	1	9	1	11	33	68
																			Mean 11-14			85.3
																			Mean total			94.9

TABLE 8. Pearson product-moment correlation coefficients between the students and the physicians' total response frequencies for items listed five times or more in each category.

Respiratory	.66	(36)[+]***	Infectious	.21	(49)
Cardiovascular	.75	(42)***	Neoplastic	.38	(37)**
Genitourinary	.69	(30)***	Inflammatory	.14	(36)
Gastrointestinal	.58	(37)***			
Endocrine	.80	(22)***			
Musculoskeletal	.47	(36)***	Dyspnea	.76	(25)***
Neurological	.17	(27)	Abdominal pain	.52	(34)***
Hematological	.64	(22)***	Joint pain	.50	(26)***

\+ Number of items in parentheses
*** $p < .001$
** $p < .01$

cian listed tracheitis while nine students did). However, these results have to be interpreted with caution because of low within group reliability measures; the split-half correlations coefficients were .28 and .37 for the students and the physicians respectively. Thus, the lower correlation obtained in the present study between the students and the physicians may be simply due to these lower reliability measures themselves, possibly a consequence of the small number of subjects as opposed to Battig and Montague's samples.

How similar or different were the particular disorders listed by the students and the physicians? Overall, an average of six of the top 10 disorders listed in each category by each subject group were common to both groups (61%). The same proportion was observed for the 20 most

frequently listed items. The commonality decreases to 53% for the five most frequent items (see Table 9). The detailed descriptive data is presented in Appendix D for the top 10 items in each category.

In summary, while some 60% of the disorders listed are common to both students and physicians, the ordering of theses disorders in each subject group seem to vary.

Since the basic difference between the two subject groups was clinical experience, it was hypothesized that the differences in the responses might be due to the fact that the physicians recalled disorders that they encountered most often in their practice setting. In other words, it was possible that the more frequent disorders were recalled first and so on. This hypothesis was all the more plausible since Elstein et al. (1978) noted that considerations of disease frequency were relatively more important than considerations of seriousness of disease or of pathophysiological processes in determining problem formulations (p. 193). The composite list of responses given by each subject group for the eight categories of organ systems disorders was compared with the most frequent disorders seen in a group of general practice patients.[1,2] Overall, there was a 55% commonality between the

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(1) Data was compiled by Marshland, Wood, and Mayo (1976) from the health care problems that 88,000 patients presented to 118 family physicians over a two-year period in the state of Virginia. A total of 526,196 problems were noted. A problem was recorded each time a patient was seen for it, either for the first time or for a follow-up. This data base is widely accepted as a representative sample of family practice in general.

(2) Responses from the remaining six categories were not compared because the appropriate population data was not available either locally or from the literature.

TABLE 9. Number of items in common for the 20, 10 and 5 most frequently listed items in each category between the students and the physicians.

Category	Top 20 items	Top 10 items	Top 5 items
Organ-systems disorders:			
1. Respiratoty	12	8	3
2. Cardiovascular	15	7	3
3. Genitourinary	13	8	3
4. Gastrointestinal	16	7	2
5. Endocrine	14	7	5
6. Musculoskeletal	11	5	3
7. Neurological	10	4	1
8. Hematological	13	8	3
Mean:	13 (65%)†	6.8 (68%)	2.9 (58%)
Pathophysiology related disorders:			
9. Infectious	8	3	2
10. Neoplastic	13	4	1
11. Inflammatory	11	4	2
Mean:	10.7 (53%)	3.7 (37%)	1.7 (33%)
Symptom related disorders:			
12. Dyspnea	13	9	3
13. Abdominal pain	12	5	3
14. Joint pain	11	7	3
Mean:	12 (60%)	7 (70%)	3 (60%)
Mean total:	12.3 (61%)	6.1 (61%)	2.6 (53%)

† Percentages in parentheses. For example, 13/20 x 100.

most frequently listed responses and the most frequent disorders in actual practice. There was no marked differences between the responses of the students and the physicians; none of the comparisons for each of the eight categories were statistically significant based on two independant sample tests for equal proportions between students and physicians (see Table 10). The same is also true at the composite level (χ^2_1= .08 and .20 for the top ten and five items respectively using the Mantel-Haenszel method of combining evidence from the eight fourfold tables).

A qualitative analysis of the responses for the top 10 items

TABLE 10 Number of items in common for the 10 and 5 most frequently mentioned items in each category between each subject group and the most frequent disorders seen in a sample of general practice patients.

	10 top items			5 top items		
Category	Students	Physicians	χ^2	Students	Physicians	χ^2
1. Respiratory	3	5	.83	2	2	.00
2. Cardiovascular	4	5	.22	3	3	.00
3. Genitourinary	9	8	.40	3	3	.00
4. Gastrointestinal	3	4	.22	2	1	.48
5. Endocrine	5	5	.00	4	4	.00
6. Musculoskeletal	4	7	1.46	3	3	.00
7. Neurological	4	5	.22	2	3	.40
8. Hematological	4	5	.22	2	4	1.67
Total:	4.5	5.5		2.6	2.9	

listed in each category was carried out independently by the experimenter and another physician. Overall, both reviewers were struck much more by the similarities in the responses than by the differences between the students and the physicians. Indeed, the items listed in the following eight categories were especially similar: respiratory, cardiovascular, genitourinary, gastrointestinal, endocrine, hematological, dyspnea, and joint pain. About three quarters of the items listed in these categories were identical. Most often, the differences were minor; for example, gastritis versus peritonitis or Wilms' tumor versus Grawitz'. There was no dominant pattern in the responses across all eight categories as, for example, lists based on anatomical localizations or major pathophysiological mechanisms. It was striking however that many of the disorders listed tended to be more general than specific, for example, pneumonia and lung cancer as opposed to bronchopneumonia and adenocarcinoma of the lungs. It was also noticeable that the items listed for dyspnea were almost the same as those for the category of respiratory disorders. More cardiovascular and musculoskeletal disorders would have been expected with dyspnea, especially by the physicians who might have seen these associations in practice.

The remaining six categories contained some noticeable differences which can be divided into three types of explanations. The differences for four of the categories (neurological, musculoskeletal, infectious, and abdominal pain) were mainly due to the influence of disease frequency. The physicians listed more frequent disorders than the students. For example, in the category of infectious disorders, the physicians listed tonsilitis, cystitis, and otitis as opposed to syphilis, T.B., and septicemia for the students. It was also noticeable that

the category of disorders related to abdominal pain contained items almost exclusively related to the digestive tract, thus omitting various other body systems etiologies such as urinary, genital, or cardiovascular.

As for the category of neoplastic disorders, the items listed were very general and mostly related to anatomical localizations such as neoplasm of the stomach, the breasts, the colon, and so on. Finally, it was obvious that neither the students nor the physicians had a clear definition of an inflammatory disorder. There was a tripartite mixture in the items listed, namely inflammations (such as bursitis or tendinitis), infections (such as pharyngitis or otitis), and inflammatory disorders (such as rhumatoid arthritis, ulcerative colitis, or Crohn's disease).

DISCUSSION AND CONCLUSION

The variability in the particular disorders listed from across subjects can be interpreted by some as a sign that the data were not reliable (in a measurement sense), or as an indication that there was indeed no internal cognitive structure. Both of these conclusions are shortsighted. The heterogeneity was a consequence of the experimental method used (free-recall). The results sought (category membership norms) arise from a composite of individual responses. Murdock (1976), in his review of the methodology used in the study of human memory, stressed that when using a free-recall technique, subjects will produce different response lists when tested repeatedly. Graesser II and Mandler (1978) reported that "the accessibility of items from well-established categories is limited, during any single retrieval phase, to

five or fewer instances..." (p. 86). Indeed, during the experimentation, it was often noted that the subjects listed the items in spurts. Murdock added that, because of the limitations of the method, a multitrial procedure is necessary to study the organization of memory. Furthermore, to draw a conclusion about the structure of memory on the sole basis of one experimental task such as free-recall can be misleading. Thus follows the necessity to design not one but a set of converging experiments as exemplified by Rosch and as was the case in the present study. The heterogeneity of the responses derived therefore from the method used and not necessarily from the underlying psychological construct. The results of this first experiment were considered valid. Indeed, the degree of agreement for the most frequently mentioned item in each category was even higher than in similar studies, probably because of the specialized nature of the knowledge involved. Hunt and Hodge (1971) reported an average of 69.7% agreement in their study of 84 word categories (range: 57 - 100). Battig and Montague (1969) obtained similar results with 56 verbal categories.

The similarities in the particular disorders listed by the students and the physicians outweighed the differences; for eight of the 14 categories, some three quarters of the responses were identical for the top 10 items in each category. There are however differences between the two groups in the level of commonality of the disorders listed (higher among physicians) and possibly in the relative emphasis given to the particular disorders in each category. Also, despite the physicians' increased clinical experience over the students, they did not tend to list in general the names of disorders that were most frequent in general practice any more so than the students did. Although there

were a lot of similarities in the responses between the students and the physicians, the different commonalities and emphasis suggest that the physicians' categories are better differentiated than the students, for example, the members would be more clearly defined. This hypothesis will be explored in the following experiments.

SUMMARY

Using a free-recall procedure, category membership norms were obtained for 14 broad categories of medical disorders. The norms were established separately for the two populations of interest - one from a sample of third-year pre-clinical medical students, the other from a sample of experienced general practitioners. The lists of category members obtained were valid and reliable in as much as they were comparable to those reported in similar studies of semantic memory.

The differences between the students and the physicians were more to be found in the level of commonality of the disorders among the subjects (higher for the physicians) and possibly in the relative emphasis given to the various disorders in each category than in the particular disorders listed. The relative frequency of occurrence in general practice of different disorders listed had an equal influence for both subject groups.

The responses listed for the 14 categories were used as the taxonomic norms for the following experiments on internal structure.

CHAPTER IV

EXPERIMENT - 2: PROTOTYPICALITY RATINGS

PURPOSE

The purpose of the second experiment, Prototypicality ratings, was to obtain a first measure of the internal structure of the 14 categories compiled in Experiment -1. Do the students and the physicians agree concerning which disorders in a category are the most prototypical? Prototypicality was operationally defined by the subject's judgment of the extent to which different instances in a category represented good examples of members of that category. The hypothesis was tested that the members of a category would be perceived as having various degrees of representativeness depending on how closely each disorder fits one's idea or image of the meaning of the category (Rosch and Mervis, 1975, p. 587). This hypothesis is contrary to the deterministic notion of categorization which assumes that each member of a category has equal membership.

SUBJECTS

Of the remaining 92 students, 16 were randomly selected to participate, of whom 13 accepted (81%). All of the 19 physicians solicited while attending a continuing medical education conference accepted.

sequence was thus rated by about 6 students and each subject rated all 14 categories.

ANALYSIS AND RESULTS

Both students and physicians found the task understandable and meaningful; none questioned or protested about the task. The actual time spent to rate the 112 items varied between five to 10 minutes, with an average of 3.5 seconds per item. The correlation between the mean ratings for each item in the two sequences was high; the Pearson product-moment correlation coefficient was equal to 0.96.

The mean rating of all instances (MRE) for each category and each sample are presented in Tables 11 and 12 for the students and the physicians, respectively. Agreement among subjects was particularly high for the items rated as very good examples of the category. All the subjects agreed perfectly in giving a rating of seven (best example) to the top item in five categories: pneumonia for respiratory disorders and appendicitis for abdominal pain in the student group; and myocardial infarction for cardiovascular disorders, leukemia for hematological disorders, and asthma for dyspnea in the physician group. A Kendall coefficient of concordance was computed for each category to measure the strength of agreement among the subjects: the median coefficients were .59 (range: .49 to .69) and .51 (range: .35 to .72) for the students and the physicians respectively (see Table 13).

Overall, the mean ratings decreased as the frequency level decreased. A Friedman test was performed to determine whether the mean ratings for the four frequency levels over all 14 categories differed

TABLE 11. Students' mean prototypicality ratings.

CATEGORY	MEMBER	TF*	MRE**	CATEGORY	MEMBER	TF*	MRE**
1. Respiratory	Pneumonie	38	7.0	5. Endocrine	Hyperthyroïdie	39	6.8
	Pneumothorax	22	6.2		Maladie de Cushing	31	6.9
	Bronchite	16	6.5		Diabète (sucré)	31	6.8
	Sidérose	5	5.6		Hémaphrodisme	5	5.0
	Membr. hyalines	4	6.0		Insuff. adrénoc.	4	6.5
	Hydrothorax	2	5.5		Adénome thyroïdien	2	5.5
	Stridor	1	4.6		Mucoviscidose	1	2.8
	Prostatite		1.0		Fissure anale		1.0
2. Cardiovascular	Infarctus myoc.	41	6.9	6. Musculoskeletal	Fractures	29	6.8
	Sténose mitrale	27	6.5		Ostéomalacie	10	6.4
	Athérosclérose	14	6.4		Bursite	9	6.2
	Myocardite	7	5.8		Ostéomyélite	5	5.9
	Tétralogie F.	5	6.0		Chondrosarcome	3	6.2
	Fibrillation auric.	2	5.8		Hallux valgus	2	5.6
	Angéite	1	4.7		Arthrite gonoc.	1	4.7
	Psoriasis		1.1		Asthme		1.0
3. Genitourinary	Pyélonéphrite	22	6.3	7. Neurological	Sclérose en plaques	26	6.7
	Uréthrite	21	6.8		Poliomyélite	10	6.5
	Vaginite	18	6.8		Méningite	7	5.6
	Orchite	4	6.2		Encéphalite	4	6.5
	Prolapsus utérin	3	5.5		Myasthénie grave	3	4.7
	Cryptorchidie	2	6.4		Méningiome	2	6.3
	Hernie inguinale	1	3.2		Hernie discale	1	5.0
	Oésophagite		1.0		Hernie ombilicale		1.0
4. Gastrointestinal	Colite ulcéreuse	28	6.9	8. Hematological	Anémie	21	6.5
	Ulcère duodénal	21	6.9		Leucémie	18	6.7
	Diverticule	7	6.2		Hémophilie	17	7.0
	Mégacolon	3	6.3		Purpura	4	6.2
	Néoplasie du panc.	3	5.1		Erythroblastose f.	3	6.2
	Hypertension port.	2	4.8		Schistocytose	2	2.5
	Sygmoïdite	1	5.9		Vasculite	1	3.8
	Sténose mitrale		1.2		Cataractes		1.2

TABLE 11 continued.

CATEGORY	MEMBER	TF*	MRE**	CATEGORY	MEMBER	TF*	MRE**
9. Infections	Pneumonie	24	6.7	12. Dyspnea	Emphysème	34	6.8
	Méningite	14	6.8		Pleurésie	7	5.6
	Septicémie	13	6.6		Bronchiectasie	5	5.0
	Pied d'athlète	4	5.5		Silicose	4	5.5
	Ostéite	3	5.5		Membranes hyalines	3	6.0
	Péritonite	2	5.3		Sténose aortique	2	4.8
	Synovite	1	3.7		Médiasténite	1	4.5
	Epistaxis		1.2		Cystocèle		1.2
10. Neoplastic	Néoplasie gastrique	19	6.8	13. Abdominal Pain	Appendicite	34	7.0
	Leucémie	10	6 0		Pancréatite	25	6.7
	Mal. de Hodgkin	6	6.0		Ulcère	7	6.0
	Lipome	4	3.1		Polypes	4	3.8
	Néphroblastome	3	6.5		Glomérulonéphrite	3	3.7
	Fibrosarcome	2	6.5		Rectite	2	3.8
	Rétinosarcome	1	6.5		Hépatite virale	1	4.4
	Glaucome		1.2		Goutte		1.0
11. Inflammatory	Arthrite	20	6.7	14. Joint pain	Arthrose	28	6.8
	Laryngite	9	6.4		Entorse	15	6.6
	Mal. de Crohn	8	6.2		Subluxation	7	5.8
	Vaginite	4	4.8		Hydarthose	3	5.8
	Epididymite	3	5.3		Ostéosarcome	3	3.5
	Allergie	2	4.8		Chondrome	1	4.5
	Ascite	1	1.7		Ostéomyélite	1	4.1
	Acromégalie		1.2		Cholélithiase		1.0

* TF: Experiment-1: total frequency.

** MRE: Experiment-2: mean rating of prototypicality.

TABLE 12. Physicians' mean prototypicality ratings.

CATEGORY	MEMBER	TF*	MRE**	CATEGORY	MEMBER	TF*	MRE**
1. Respiratory	Emphysème	18	6.7	5. Endocrine	Hypothyroïdie	21	6.7
	Pneumonie	17	6.9		Diabète sucré	18	6.3
	Pneumothorax	14	6.7		Mal. de Cushing	12	6.7
	Embolie pulm.	6	6.4		Adénome hypophysaire	3	6.7
	Amiantose	6	6.3		Phéochromocytome	3	6.5
	Histoplasmose	2	5.6		Testicule féminisant	1	6.4
	Sinusite	1	4.3		Syndrome Z.-Ellison	1	4.2
	Prostatite		1.0		Fissure anale		1.0
2. Cardiovascular	Infarctus myoc.	18	7.0	6. Musculoskeletal	Tendinite	17	6.0
	Angine de poitrine	17	6.7		Fractures	16	6.7
	H.T.A.	9	6.3		Entorse	11	6.4
	Sténose mitrale	8	6.3		Goutte	5	4.5
	Tétralogie de F.	4	6.2		Spondylite ankyl.	4	5.8
	Fibrillation auric.	4	6.1		Ostéomalacie	2	5.7
	Angéite	1	4.7		Rachitisme	1	5.9
	Psoriasis		1.0		Asthme		1.0
3. Genitourinary	Cystite	17	6.5	7. Neurological	Sclérose en plaques	17	6.8
	Pyélonéphrite	16	6.4		Méningite	8	5.9
	Vaginite	8	6.2		Céphalée de tension	8	3.5
	Orchite	5	6.1		Méningiome	3	6.6
	Cystocèle	4	6.2		Poliomyélite	2	6.4
	Hydrocèle	2	5.5		Glioblastome	1	6.3
	Prolapsus utérin	1	6.0		Hernie discale	1	4.9
	Oésophagite		1.0		Hernie ombilicale		1.0
4. Gastrointestinal	Colite ulcéreuse	14	6.8	8. Hematological	Leucémie	12	7.0
	Diverticule	12	5.7		Anémie	12	6.6
	Ulcère duodénal	9	6.8		Hémophilie	5	6.9
	Néoplasie gastrique	8	6.3		Purpura	3	6.3
	Hernie hiatale	7	5.8		Myélome multiple	2	6.1
	Abcès anal	2	4.8		Anisocytose	1	5.6
	Mégacolon	1	6.2		Toxoplasmose	1	2.2
	Sténose mitrale		1.0		Cataractes		1.0

TABLE 12. continued.

CATEGORY	MEMBER	TF*	MRE**	CATEGORY	MEMBER	TF*	MRE**
9. Infections	Amygdalite	18	6.4	12. Dyspnea	Asthme	16	7.0
	Sinusite	12	5.9		Bronchite chronique	10	6.1
	Otite	11	6.7		Pleurésie	4	5.0
	Prostatite	6	6.1		Membranes hyalines	3	6.8
	Adénite	3	5.6		Sarcoïdose	3	4.2
	Péritonite	2	6.1		Bronchiectasie	1	4.3
	Septicémie	1	6.9		Sténose aortique	1	4.2
	Epistaxis		1.2		Cystocèle		1.2
10. Neoplastic	Mal. de Hodgkin	12	6.4	13. Abdominal pain	Appendicite	19	6.9
	Néoplasie du panc.	8	6.9		Pancréatite	17	6.8
	Oat cell	7	6.8		Ulcère gastrique	9	6.4
	Hépatome	6	6.2		Diverticule de Meckel	6	5.2
	Néphrosarcome	2	6.7		Endométrite	5	5.9
	Chondrosarcome	1	6.5		Hépatite	3	5.3
	Schwanome	1	5.2		Hernie inguinale	2	4.5
	Glaucome		1.2		Goutte		1.0
11. Inflammatory	Bursite	15	6.5	14. Joint pain	Arthrite rhumatoïde	16	6.6
	Tendinite	12	6.3		Déchirure méniscale	11	6.5
	Mal. de Crohn	7	6.3		Arthrose	10	6.4
	Lupus érythémateux	5	5.3		Luxation	4	6.4
	Myosite	2	6.2		Hydarthrose	4	5.7
	Exzéma	1	4.6		Dermatomyosite	1	4.2
	Allergie	1	4.4		Sclérodermie	1	4.2
	Acromégalie		1.2		Cholélithiase		1.0

* TF: Experiment-1: total frequency.

** MRE: Experiment-2: mean rating of prototypicality.

TABLE 13. Coefficients of concordance for the ratings assigned in each category.

CATEGORY	STUDENTS	PHYSICIANS
1. Respiratory	.56*	.55*
2. Cardiovascular	.55*	.52*
3. Genitourinary	.63*	.35*
4. Gastrointestinal	.62*	.50*
5. Endocrine	.69*	.46*
6. Musculoskeletal	.50*	.44*
7. Neurological	.57*	.63*
8. Hematological	.60*	.65*
9. Infectious	.64*	.42*
10. Neoplastic	.56*	.41*
11. Inflammatory	.63*	.46*
12. Dyspnea	.49*	.72*
13. Abdominal pain	.68*	.54*
14. Joint pain	.59*	.58*

* $p < 0.001$

significantly[1]. The tests for the students and the physicians were both significant (students: $\chi^2_R = 32.9$, $p < .001$; physicians: $\chi^2_R = 26.9$, $p < .001$); and as shown in Table 14, the trend is indeed to the effect that the mean ratings decrease as the frequency level decreases.

As expected, the most frequent item in each category and the item outside the category were rated at the two extremes of the scale. As in previous studies of this kind (Rosch, 1973, 1975c), the ratings were generally skewed toward the upper end of the scale. Excluding the outside item in each category, the mean total ratings ranged from 6.76 to 4.70 for the students (spread of 2.05) and from 6.66 to 5.17 for the physicians (spread of 1.49). The physicians used a narrower range of points on the scale than the students (Wilcoxon matched-pairs signed-ranks test formed by the 14 categories: $T = 18$, $p < .05$).

Finally, correlations were computed between the mean rank of prototypicality in this rating task and the mean rank output of the disorders in the first experiment. The median Spearman rank-order correlation coefficients were .83 for the students and .85 for the physicians (see Table 15).

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(1) "Were there no agreement between subjects in ranking a given instance, that instance should have received an equal number of ratings in all seven places on the scale. The extent to which the actual distribution of ratings departs from that expected distribution, represents the degree of nonrandomness (agreement) in ratings" (Rosch, 1973, p. 132).

TABLE 14. Summary results of mean prototypicality ratings.

	Students					Physicians				
	Frequency range from first experiment									
	Top	High	Mod.	Low	Out	Top	High	Mod.	Low	Out
Categories										
1. Respiratory	7.0	6.35	5.80	5.05	1.0	6.7	6.80	6.35	4.95	1.00
2. Cardiovascular	6.9	6.45	5.90	5.25	1.0	7.0	6.50	6.25	5.40	1.05
3. Genitourinary	6.3	6.80	5.85	4.80	1.0	6.5	6.30	6.15	5.75	1.00
4. Gastrointestinal	6.9	6.55	5.70	5.35	1.2	6.8	6.25	6.05	5.50	1.05
5. Endocrine	6.8	6.85	5.75	4.15	1.0	6.7	6.50	6.60	5.30	1.00
6. Musculoskeletal	6.8	6.30	6.05	5.15	1.0	6.0	6.55	5.15	5.80	1.20
7. Neurological	6.7	6.05	5.60	5.65	1.0	6.8	4.70	6.50	5.60	1.00
8. Hematological	6.5	6.85	6.20	3.15	1.0	7.0	6.75	6.20	3.90	1.20
9. Infectious	6.7	6.70	5.50	4.50	1.2	6.4	6.30	5.85	6.50	1.40
10. Neoplasms	6.8	6.00	4.80	6.50	1.2	6.4	6.85	6.45	5.85	1.05
11. Inflammations	6.7	6.30	5.05	3.25	1.2	6.5	6.30	5.75	4.50	1.20
12. Dyspnea	6.8	5.30	5.75	4.65	1.2	7.0	5.55	5.50	4.25	1.00
13. Abdominal pain	7.0	6.35	3.75	4.10	1.0	6.9	6.60	5.55	4.90	1.30
14. Joint pain	6.8	6.20	4.65	4.30	1.0	6.6	6.45	6.05	4.20	1.05
Mean total:	6.76	6.36	5.45	4.70	1.07	6.66	6.31	6.03	5.17	1.11

TABLE 15 Spearman rank-order correlation coefficients between mean prototypicality ratings and mean rank outputs (n = 7).

	STUDENTS	PHYSICIANS
1. Respiratory	.93**	.93**
2. Cardiovascular	.97**	.99**
3. Genitourinary	.60*	.94**
4. Gastrointestinal	.80**	.51
5. Endocrine	.81**	.57*
6. Musculoskeletal	.94**	.57*
7. Neurological	.72**	.36
8. Hematological	.81**	.93**
9. Infectious	.96**	.08
10. Neoplastic	.01	.49
11. Inflammatory	.94**	.95**
12. Dyspnea	.84**	.91**
13. Abdominal pain	.72**	.89**
14. Joint pain	.86**	.97**

** $p < .025$

* $p < .05$

DISCUSSION AND CONCLUSION

Both the students and the physicians found the rating task meaningful and made highly reliable judgments about the degree of exemplariness of the various disorders in the 14 categories. In a wider sense, the results, like those obtained by Rosch (1973), suggest that from a psychological perspective, the 14 categories are composed of disorders with varying degrees of membership as expressed by the various ratings of exemplariness. The members with the highest ratings would constitute the prototypes and represent the core meaning of the category. For example, for the category of dyspnea-related disorders, asthma and chronic bronchitis are the central or prototypical members as opposed to sarcoidosis and bronchiectasis. The following experiments will add further evidence for or against this type of internal structure.

In her study of the internal structure of semantic categories, Rosch (1973) states that the significant correlations she obtained between the mean rank of exemplariness and the mean rank output may be a spurious result because she did not randomly sample the instances. In the present study, however, the instances for each of the three established frequency ranges were randomly selected and both the students and the physicians exhibited positive correlations between ranks and outputs. As Rosch (1973) suggested, this relationship is yet another argument to support the notion of prototypicality; that is, the prototypes tend to be recalled earlier and more often in a free-recall task than the less prototypical items (Rosch, 1973; Mervis, Catlin and Rosch, 1976).

The fact that the physicians used a narrower range of points on the rating scale than the students did (1.49 versus 2.05) suggests that

the disorders in the physicians' memory may be closer together than those of the students. This hypothesis is plausible since the physicians had more opportunities to associate the various disorders with their category name than the students. If this hypothesis is tenable, it should also be noticeable in the time needed to access the various points in the category. Response time will be tested in the last experiment.

SUMMARY

Using a 7-point rating scale, both the students and the physicians found the rating task meaningful and made reliable judgments about the degree of exemplariness of seven randomly selected disorders taken from each of the 14 categories for which instances were collected in the first experiment.

These results suggested that from a psychological perspective, the 14 categories were composed of disorders with varying degrees of membership. The significant correlations between the ratings in this task and the mean output rank in the free-recall task lended additional support to the notion of prototypicality in that the instances with the highest ratings in a category were recalled sooner and more often than the instances with the lower ratings.

The fact that the physicians used a narrower range of points on the rating scale suggested that their network of knowledge has greater intracategory associative strength than the students.

CHAPTER V

EXPERIMENT - 3: FAMILY RESEMBLANCE

PURPOSE

The purpose of the third experiment, Family resemblance, was to obtain a description of the attributes (signs, symptoms, etc.) of the disorders studied in the preceding experiment and to test two hypotheses concerning these attributes. First, Wittgenstein's concept of a family resemblance structural relationship was tested. According to this hypothesis, each disorder in a category should have at least one, if not several, attributes in common with one or more other disorders, but there should be no, or few, attributes common to all disorders. This hypothesis is a direct test of the conflicting notion that categories are defined, according to the deterministic view, by necessary and jointly sufficient criterion attribute(s) as opposed to categories being defined by an overlapping network of attributes of the type AB BC CD DE, the family resemblance structure. Second, the hypothesis was tested that the disorders with the highest prototypicality ratings in a category are those with the most attributes in common with the other members of the category (but not necessarily common to all members).

SUBJECTS

Of the remaining 76 students, 60 were randomly selected to participate, of whom 31 accepted (52%). Of the 30 physicians solicited, 23 accepted (77%).

STIMULI

Based on the prototypicality ratings, six of the seven items in each of the 14 categories were selected separately by subject type and according to the following distribution: the two items with the lowest ratings, the two intermediate ones, and two of the three top rated items. These last two items were randomly selected. The six instances from each category along with their prototypicality ratings are presented in Appendix E.

INSTRUCTIONS

Subjects were asked to list the attributes belonging to each disorder. The experiment was conducted in French. A modified version of Rosch and Mervis' instruction set (1975) was used[1]:

> There are 42 pages in this booklet. At the top of each page you will be given the name of a disorder found in medicine (disease, pathology, problem). For each disorder, please proceed as follows:
>
> 1- Read the name of the disorder.
>
> 2- Write down legibly the name of all the attributes of that disorder that you can think of, including the presence or the absence of symptoms or signs, pathophysiology, laboratory tests, anatomy etc., but excluding treatments. You will have a minute and a half to write down these attributes using one line per attribute. Do not pay any attention to misspellings; strike out a mistake rather than erase it.
>
> 3- When you hear the signal indicating the end of the minute and a half period, stop writing and turn immediately to the next page of the booklet.
>
> 4- Repeat the preceding steps for each one of the 42 disorders. Here is an example:

---

(1) The actual French instructions are available upon request.

CHAIR		
legs	sitting	metal
back	cushion	wood
seat	Kitchen	desk

In the example, the subject listed a certain number of attributes suggested by the item proposed. These answers are neither right nor wrong. They are the subject's spontaneous expression. He could have listed more or less items depending on how many came to his mind at the time.

Do not stop to think why you may answer in a certain way. Do not pay any attention to what others may think. Write down your answers as they spontaneously come to your mind.

PROCEDURE

Each of the 84 items was printed at the top of a page with the pages assembled into two separate booklets containing 42 items each. The 42 items were evenly distributed across the 14 categories and across the three levels of prototypicality in each category. Thus, each booklet contained one item from each level of protypicality (high, moderate, and low) in each of the 14 categories. The items in each booklet were randomly ordered. The booklet also contained a short demographic questionnaire and a set of instructions.

Each subject received one of the two booklets (42 items), answered the questionnaire, and read the instructions. The experimenter then answered any questions to clarify the procedure; however, questions were rarely asked. Each subject then completed the 42 items with the one and a half minute pacing being signaled by the experimenter in front of the room. Because of the extensive writing involved, a five-minute break

was given midway through the task, but no discussion of the experiment was allowed. Subjects were tested in groups ranging in size from two to 13 persons. Experimental sessions lasted about one hour and twenty minutes.

Each item was thus completed by roughly 27 subjects, about 15 students and 12 physicians.

ANALYSIS AND RESULTS

The same criteria used to tabulate the responses in Experiment - 1 were applied to the present data.

Results were tabulated separately for each disorder and for each sample and included:

1- A list of all separate responses presented in decreasing order of frequency.

2- For each response, three measures were computed:

F : Frequency of occurrence of the response for the entire sample;

F1 : Number of times each response was mentioned first in the response sequence output;

MR : Mean rank position of response in the sequence of responses given by each subject.

A total of some 6,450 responses were recorded by the experimenter. Approximately five percent of these responses were drawn from randomly selected instances (Pyelonephritis, Multiple sclerosis, Diabetes mellitus, and Inguinal hernia) and were independently retabulated by another physician (the same as for the first experiment). The second rater agreed with an average of 96.6% of the experimenter's tabulations for each instance (range: 94.8 to 97.9). There were no systematic

errors of interpretation in the disagreements. Most discrepancies were due to the omission of a response by one of the two raters; rarely were new items added by the reviewer (17 items altogether). Synonyms were rarely a problem (8 instances altogether).

In the first booklet (42 items), each student listed an average of 7.7 attributes per disorder as opposed to 8.9 for the physicians (repeated measures ANOVA: $F(1,24)= 1.13$, $p = .30$). In the second booklet (42 items), each student listed an average of 8.4 attributes per disorder as opposed to 9.4 for the physicians (repeated measures ANOVA: $F(1,26)= 1.09$, $p = .31$).[1] (In both cases, there was a significant interaction between subject type and the individual disorders).

INTERNAL STRUCTURE: FAMILY RESEMBLANCE

Few of the attributes listed either by the students or the physicians were common to all six disorders in a category. For the students, only five categories contained such common attributes; for the physicians, only three categories. Usually, a particular attribute was listed for only one or two disorders in a category (see Table 16). This can be seen clearly in Figure 1 which contains a frequency distribution of number of attributes (averaged over categories) as a function of the number of disorders (1-6) in each category sharing the attribute. It is apparent in the figure that the number of attributes which were listed for x disorders in a category decreases regularly as x increases.

---

(1) The entire set of results is available upon request. A tabulation for one of the disorders is presented as an example in Appendix F.

TABLE 16 Frequency distribution for the number of attributes applied to each number of disorders in a category. †

STUDENTS

Number of disorders sharing the attribute:	6	5	4	3	2	1
1. Respiratory	2 [1]	2	3	7	36	235
2. Cardiovascular	0	1	1	8	32	244
3. Genitourinary	0 [2]	0	0	10	36	209
4. Gastrointestinal	1	1	4	16	35	239
5. Endocrine	0	0	2	6	32	309
6. Musculoskeletal	0	1	3	9	19	238
7. Neurological	0	1	4	8	28	252
8. Hematological	0	1	2	8	19	288
9. Infectious	1 [3]	3	3	8	23	227
10. Neoplastic	1 [4]	2	5	5	27	225
11. Inflammatory	0	0	1	7	16	301
12. Dyspnea	1 [5]	0	3	6	24	295
13. Abdominal pain	0	1	2	9	30	300
14. Joint pain	0	2	6	11	28	206

PHYSICIANS

1. Respiratory	1 [6]	2	8	8	25	254
2. Cardiovascular	0	1	1	13	37	252
3. Genitourinary	0	1	2	15	22	198
4. Gastrointestinal	0	1	8	13	30	243
5. Endocrine	0	0	1	6	28	261
6. Musculoskeletal	0	0	2	5	37	250
7. Neurological	0	0	4	12	31	283
8. Hematological	0	2	5	9	33	246
9. Infectious	1 [7]	2	4	10	23	288
10. Neoplastic	0	3	3	12	12	244
11. Inflammatory	0	0	3	5	33	284
12. Dyspnea	1 [8]	3	2	3	29	271
13. Abdominal apin	0	1	8	9	32	259
14. Joint pain	0	3	8	16	36	217

† Note: The attributes common to all six members are referenced below.

(1) Dyspnea and lungs
(2) Obstruction
(3) Infection
(4) Neoplasms
(5) Dyspnea
(6) Cough
(7) Fever
(8) Dyspnea

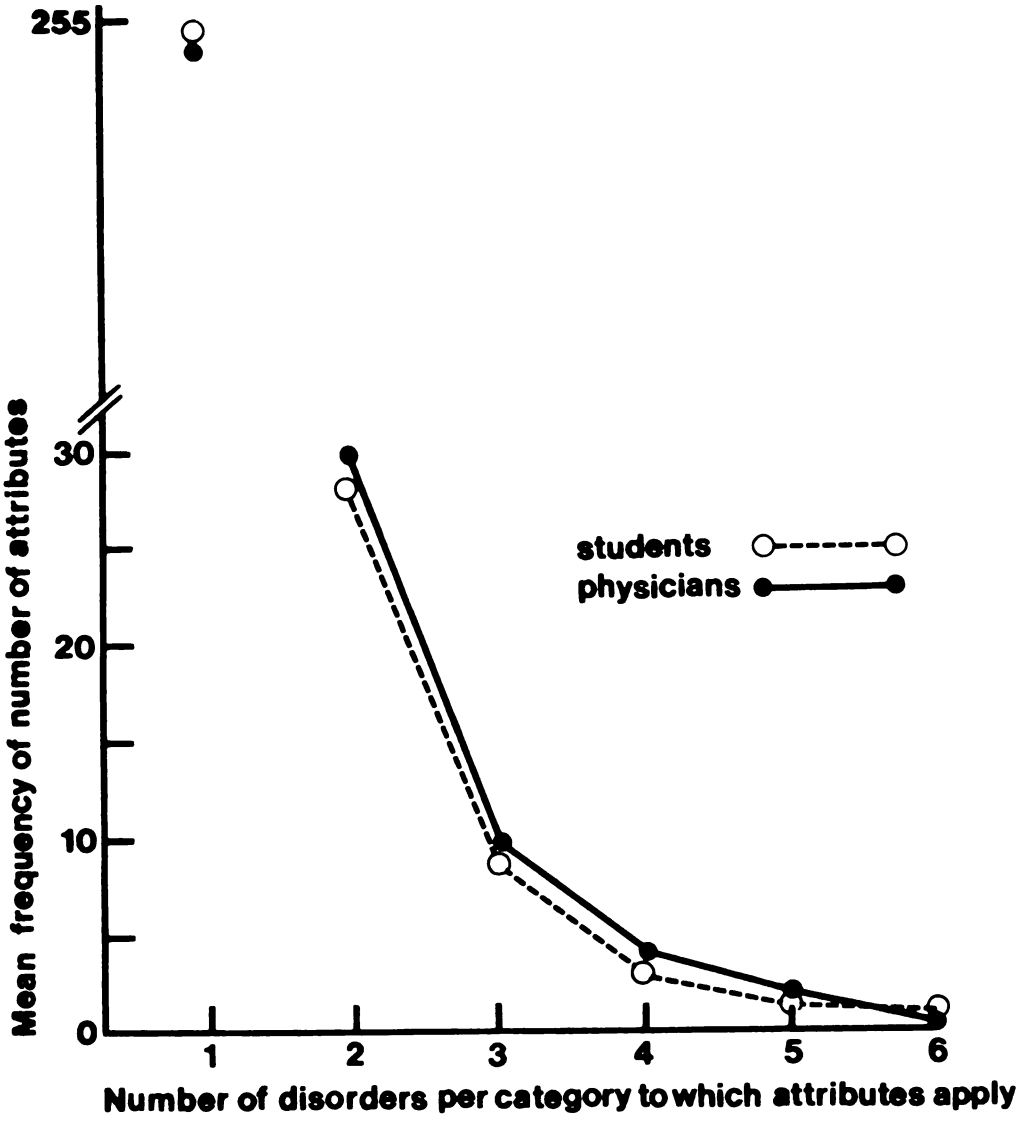

Figure 1. Frequency distribution for the mean number of attributes applied to each number of disorders per category.

PROTOTYPICALITY - FAMILY RESEMBLANCE

To derive the measure of family resemblance, all the attributes mentioned by the subjects for each disorder in each category were tabulated; each sample was compiled separately. Following Rosch and Mervis' (1975) procedure, each attribute received a score ranging from 1 to 6, representing the number of disorders in a category which shared that attribute. Accordingly, each attribute was weighted in accordance with

the number of members in the category possessing it. The measure of degree of family resemblance for a given disorder was the sum of the weighted scores of each of the attributes that were listed for that item.[1] Attributes with scores of one or two were not included in the final tabulation because with two disorders per level of prototypicality in each category, a score of at least three was needed to show that an attribute was common beyond any one level of rated prototypicality. Furthermore, unique attributes do not contribute to the structure of the categories as a whole (Rosch and Mervis, 1975, p. 581). The scores for all 84 disorders are presented in Tables 17 and 18 for the students and the physicians, respectively.

To assess the relationship between Prototypicality and Family resemblance, correlations between prototypicality ratings and family resemblance scores were computed separately for each category and each sample. The median Spearman rank-order correlation coefficients between the two measures were equal to .62 for the students (range= .87 to -.09) and .59 for the physicians (range= 1 to -.20). Nine of the 14 correlations were statistically significant at the .05 level for the students (H_o: ratings and scores are mutually exclusive); and seven of the 14 for the physicians (see Table 19). Of the statistically significant categories, four were common to both samples: respiratory, cardiovascular, genitourinary and inflammatory.

Overall, the higher the mean prototypicality rating of an item, the higher the mean family resemblance score. Indeed, using the 14

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(1) Each family resemblance score was not weighted according to the number of subjects that listed the attribute; consequently, the fact that a single subject mentioned an attribute was sufficient to credit the disorder with that attribute.

TABLE 17. Students' family-resemblance scores at each level of prototypicality.

Category	High prototypicality ratings		Moderate prototypicality ratings		Low prototypicality ratings	
1. Respiratory	48	54	33	30	40	27
2. Cardiovascular	30	24	14	18	17	13
3. Genitourinary	18	6	21	15	15	15
4. Gastrointestinal	51	50	38	60	42	30
5. Endocrine	23	8	13	16	16	10
6. Musculoskeletal	38	24	32	28	11	21
7. Neurological	28	36	31	22	22	22
8. Hematological	25	25	25	17	7	30
	(32.6)†	(28.4)	(25.9)	(25.8)	(21.3)	(21)
	(30.5)		(25.8)		(21.1)	
9. Infectious	44	37	45	31	43	31
10. Neoplastic	38	45	40	34	31	23
11. Inflammatory	19	13	22	19	6	3
	(33.7)	(31.7)	(35.7)	(28)	(26.7)	(19)
	(32.7)		(31.8)		(22.8)	
12. Dyspnea	20	33	30	27	10	15
13. Abdominal pain	31	31	24	18	13	21
14. Joint pain	35	52	32	45	44	37
	(28.7)	(38.7)	(28.7)	(30)	(22.3)	(24.3)
	(31.6)		(29.3)		(23.3)	
TOTAL:	32	31.3	28.6	27.8	23.6	21.3
	(31.7)		(27.9)		(22)	

† Average scores in parentheses.

TABLE 18. Physicians' family-resemblance scores at each level of prototypicality .

Category	High prototypicality ratings		Moderate prototypicality ratings		Low prototypicality ratings	
1. Respiratory	58	55	40	50	51	33
2. Cardiovascular	36	33	30	17	30	12
3. Genitourinary	49	45	40	29	16	12
4. Gastrointestinal	57	46	53	36	57	21
5. Endocrine	19	9	16	7	13	6
6. Musculoskeletal	20	17	6	11	10	13
7. Neurological	17	45	20	39	30	30
8. Hematological	51	44	29	40	16	30
	(38.4)†	(36.8) (37.6)	(29.3)	(28.6) (28.9)	(27.9)	(19.6) (23.8)
9. Infectious	36	45	46	30	30	53
10. Neoplastic	35	52	44	50	44	31
11. Inflammatory	14	21	14	17	13	14
	(28.3)	(39.3) (33.8)	(34.7)	(32.3) (33.5)	(29)	(32.7) (30.8)
12. Dyspnea	40	26	32	33	36	24
13. Abdominal pain	54	50	27	36	55	12
14. Joint pain	86	60	51	64	58	30
	(60)	(45.3) (52.7)	(36.7)	(44.3) (40.5)	(49.7)	(22) (35.8)
TOTAL:	40.9	39.1 (40)	32	32.8 (32.4)	32.8	22.9 (27.9)

† Average scores in parentheses.

TABLE 19. Spearman rank-order correlation coefficients between prototypicality ratings and family-resemblance scores for each category (n = 6).

	STUDENTS	PHYSICIANS
1. Respiratory	.77**	.77**
2. Cardiovascular	.87**	.87**
3. Genitourinary	.60*	1.00**
4. Gastrointestinal	.53	.44
5. Endocrine	.11	.64*
6. Musculoskeletal	.76*	.49
7. Neurological	.76*	-.20
8. Hematological	.04	.71*
9. Infectious	.44	-.09
10. Neoplastic	.71*	.33
11. Inflammatory	.64*	.71*
12. Dyspnea	.60*	.43
13. Abdominal pain	.86*	.37
14. Joint pain	-.09	.69*

** $p < .025$

* $p < .05$

categories as observations, Friedman tests were statistically significant for both the students and the physicians thus indicating that the scores for each level of prototypicality were statistically different from one another (students: $\chi^2_R = 17.3$, $p < .001$; physicians: $\chi^2_R = 21$, $p < .001$); and as shown in Tables 17 and 18, the trend is to the effect that the mean scores decrease as the prototypicality level decreases. Furthermore, the mean scores obtained by the physicians were higher than those of the students (Sign test for the 84 pairs of scores: $z = 3.38$, $p = .0007$).

DISCUSSION AND CONCLUSION

The striking structural feature of these 14 categories of medical disorders is not in the presence of criterial attributes common to all the disorders in a category. Instead, the structure of the categories resides in a family resemblance relationship where most attributes are common to only some of the disorders.

The correlations between prototypicality and family resemblance are not as strong as those obtained by Rosch and Mervis (1975).[1] However, there is for the most part a significant positive correlation between the two variables in the results obtained in the present study. That is, the higher the level of prototypicality, the greater the mean number of attributes the disorder has in common with the other disorders in the category. Quite possibly, the lower correlations of the present study as compared to those of Rosch and Mervis were due to reduced

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(1) The correlations in their study were: "furniture, .88; vehicle, .92; weapon, .94; fruit, .85; vegetable, .84; clothing, .91" (p. 582).

precision resulting from use of fewer items per category: six per category for this study versus 20 per category for Rosch and Mervis. A qualitative analysis of the few sharp reversals in the family resemblance scores with regard to prototypicality levels failed to produce any specific explanation for these. The reversals were randomly distributed across levels and categories and no single factor could account for these such as, for example, an increase (or decrease) in the score would follow a corresponding increase (or decrease) in disease frequency. While further experimentation is in order, the current study definitely indicates a positive relationship between the mean prototypicality ratings and the mean family resemblance scores.

The measure of family resemblance is derived from a composite of individual responses. Consequently it could be argued by some that the results obtained are but an artifact due to the combination of data from individual subjects. Results obtained by Berlin and Kay (1969) and McCloskey and Glucksberg (1978) in a related area of investigation (that is, category boundaries or fuzzy sets) suggest that the results would be the same whether or not it was a group measure or a within-subject measure.

Finally, the higher mean scores obtained by the physicians ($\bar{z}$= 3.38; $p = .0007$) indicate that their network of knowledge about disorders is richer in the sense that they have more interconnections than the students. This finding is in agreement with past investigations on the effects of experience on memory (Elstein, Loupe, and Erdmann, 1971; Wortman and Greenberg, 1971; Johnson, 1980).

SUMMARY

Using a free-recall procedure and a scoring technique developed by Rosch and Mervis (1975), the results indicated that the striking structural feature of the 14 categories was not in one or more criterion attributes common to all the disorders in a category but in a family resemblance relationship where many attributes were true to some, but not all, of the members. There was also an overall significant positive correlation between levels of prototypicality and family resemblance; that is, the disorders with the higher prototypicality ratings were also the ones with the greatest number of attributes in common with the other members of a category. However, the inconclusive nature of some of the correlations indicates the need for further experimentation.

As noted in previous investigations, the physicians had a richer network of knowledge than the students as measured by the greater number of interconnections among the disorders in a category.

CHAPTER VI

EXPERIMENT - 4: RESPONSE TIME

PURPOSE

The evidence gathered in the preceding experiments directly addressed the issue of prototypes as a means of representing the internal structure of medical categories. The object of this last experiment was to test the effect of prototypicality on the processing of the category instances. If categories are viewed in terms of their clear cases whereby some instances have a greater degree of membership than others, then it would be expected that the time needed to access various members would vary depending on their relative position in the category. The speed with which subjects can make judgments about category membership statements has been a widely used measure of processing in semantic memory (Landauer and Freedman, 1968; Collins and Quillian, 1969; Meyer, 1970; Rips, Shoben, and Smith, 1973; Smith, Rips, and Shoben, 1974). Rosch and co-workers (1973; Rosch and Mervis, 1975; Rosch, et al., 1976b) have shown for noun concepts and artificial categories that response times for true statements of the form "A (member) is a (category)" were faster when the member is a central one (highly prototypical) than when it is peripheral (less prototypical). The purpose of this fourth experiment, Response time, was to test the hypothesis that prototypicality predicts response times to category membership statements. Again, this hypothesis highlights the conflicting notions of the

deterministic versus prototypical view of categorization. The full and equal membership assumptions of the deterministic view would suggest that the members are all equally accessible.

SUBJECTS

Of the remaining 16 students, all were selected to participate, of whom 14 accepted (88%). Of the 15 physicians solicited while attending a continuing medical education conference, 14 accepted (93%).

STIMULI

Four instances from each category were selected from the second experiment: two instances rated as good examples of the category (mean rating > 6.0), and two instances rated poorer examples (mean rating < 6.0), respectively the central and peripheral instances. Within a given range (for example, mean rating > 6.0), the disorders were selected randomly. Separate lists were prepared for the students and the physicians. The two central and two peripheral instances for each category are presented in Appendix G.

Each instance was then transformed into a true statement of the type "Diabetes mellitus is a kind of endocrine disorder," thus yielding a total of 28 true central statements and 28 true peripheral statements.

In addition, 28 false statements were constructed of the type "Otitis media is a kind of gastrointestinal disorder." The items for the false statements were obtained by randomly selecting 28 disorders from the data in the first experiment and by assigning a category name other than the one or ones it was originally associated with. The 28 resulting false statements were independently verified by three physi-

cians to ensure that no association existed between the two elements of the statement. The false statements were common to both samples and are listed in Appendix H.

Finally, two slates of 56 items each were drawn. One was composed of the 28 true central statements plus the 28 false statements, the Central set; the other was composed of the 28 true peripheral statements plus the same 28 false statements, the Peripheral set. Each slate of 56 statements so constructed consisted of an equal number of true and false statements, and each slate shared the same false statements. Therefore, by holding constant the false statement across slates, the differences in response times between these two sets could be attributed to the Central-Peripheral difference.

INSTRUCTIONS

Using true-false statements, subjects were asked to judge whether or not an instance belonged to a given category. The experiment was conducted in French. Specific instructions were[1]:

> The following pages contain 56 true-false statements. For example: "Angina pectoris is a kind of cardiovascular disorder." For each statement, please proceed as follows:
>
> 1- Read the statement.
>
> 2- If you think that the statement is true, circle the letter T to the right of the statement. Otherwise, if you think that it is false, circle the letter F.
>
> 3- Do not skip a statement. You must answer each statement one after the other. You cannot go back. When in doubt, you must take a chance and select the answer that you feel is the best. You must answer each statement.

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(1) The actual French instructions are available upon request.

4- Repeat the preceding steps for each one of the 56 statements.

5- Upon completion of the 56 statements, do not go back to make corrections. Instead, write down the time indicated on the chronometer placed in front of the room. Write the minutes and seconds in the appropriate spaces on the bottom of the last page. Work at your own pace. Never mind how long your colleagues may take. Your list is different from theirs.

PROCEDURE

Each of the two slates of 56 statements (Central and Peripheral set) was assembled into a separate booklet along with a short demographic questionnaire and a set of instructions. The statements in each booklet were randomly sequenced. Each subject randomly received one of the two booklets, answered the questionnaire, and read the instructions. Subjects were tested in groups and all started to rate the statements at the same moment. An average experimental session lasted from 8 to 10 minutes.

Each set of central and peripheral items was thus completed by 7 students and 7 physicians.

ANALYSIS AND RESULTS

Response times were analysed by means of a two-way analysis of variance (replicated fixed-effects layout) with two factors: subjects (students and physicians) and instances (central and peripheral). There was no significant interaction between the two factors ($F(1,24) = .68$, $p > .1$). Both main effects were significant. It took an average of one-half less time for the students, and one-third less time for the physicians, to respond to central statements than it did for the peripheral ones ($F(1,24) = 5.07$, $p < .05$). The mean response times were shorter for the physicians than for the students ($F(1,24) = 9.24$, $p < .01$). See

Table 20 (left-hand column). Since the students in each treatment group (central and peripheral sets) were different, their respective GPA scores were compared to verify their pre-treatment equivalence (within error variance) even though they were randomly selected and assigned. The average GPA scores were 4.2 (s = .42) and 4.3 (s = .3) respectively. The two sets of scores did not vary significantly ($t(12) = .516$; $p < .5$).

TABLE 20. Mean response times and error proportions for central and peripheral sets.

	RESPONSE TIMES (in seconds)	ERROR PROPORTIONS	
		False for a true item	True for a false item
STUDENTS			
Central (n=7)	222.9 (25)+	.016	.000
Peripheral (n=7)	338.6 (116.6)	.269	.006
PHYSICIANS			
Central (n=7)	180.1 (55.7)	.031	.006
Peripheral (n=7)	246.4 (88.2)	.181	.006

+ Standard deviations in parentheses.

While the error rate for the false statements was practically nil in the two sets, the error rate for the true statements was greater for the peripheral set than for the central one: some 20 times greater for the students and 17 times for the physicians (both Mann - Whitney U-

tests were significant; $U = 0$, $p < .001$). The false statements were clearly wrong. See Table 20 (the two right-hand column).

DISCUSSION AND CONCLUSION

The results, both for the students and the physicians, are similar to those obtained by Rosch (1973) and substantiate the prediction that it takes less time to judge that a good example of a category belonged to that category than it does to judge a peripheral one. Furthermore, a greater number of misclassifications occurred with the peripheral items than with the central ones. The increased error rate for the peripheral instances is yet another finding in favor of the concept of prototypicality; that is, the further away the item to be classified is from the prototypes, the greater are the chances of making a misclassification and vice versa.

In as much as reaction time is an indication of the associative strength among the various members of a category, the faster response times for the physicians suggest that the items in their network of knowledge are closer together than those of the students. This finding corroborates the previous results on prototypicality ratings when it was first observed that the physicians had a tighter network.

SUMMARY

Using true-false statements of the type, "Diabetes mellitus is a kind of endocrine disorder," prototypicality predicted the response times for making judgments about category membership. It took an average of one-half less time for the students and one-third less time for the physicians to make judgments about the category membership of cen-

tral, or highly prototypical disorders, as opposed to peripheral ones. Also, while the judgments were virtually error-free for the central members, significantly more errors were made for the peripheral items than for the central ones: 20 and 17 times more errors for the students and the physicians, respectively.

As previously noted in the prototypicality-rating experiment, the faster response times for the physicians in this experiment suggested that their network of knowledge was more tightly woven than for that of the students.

CHAPTER VII

GENERAL DISCUSSION AND IMPLICATIONS

The results of the present study will be discussed in relation to four topics: the psychology of categorization and memory, the differences between experts and novices, the implications for the conduct of medical education, and the implications for future research.

THE PSYCHOLOGY OF CATEGORIZATION AND MEMORY

The basic assumption associated with the traditional deterministic view of categorization is that a category is defined by a number of criterial attributes (singly necessary and jointly sufficient) and that any instance sharing these attributes has full and equal membership status. Thus, once a category is defined, one is able to determine whether or not an item belongs to the category by determining whether it possesses the criterial attribute(s). The results of the present study failed to support these assumptions.

Few attributes were listed either by the medical students or the general practitioners which were common to all the disorders in a category. Only rarely was an attribute common to all, or even to the majority, of the disorders in a category. The striking structural feature of the 14 medical categories studied was not the presence of defining or criterial attributes but rather the presence of many attributes common to some but not all category members.

The results in each of the four experiments supported a prototypical notion of categorization. The students and the physicians made reliable judgments about the degrees of exemplariness (prototypicality) of the various disorders in each category. From a psychological perspective, these ratings suggest that the disorders were not all viewed as equally representative of the category; some were more typical than others (for example, pneumonia is more typical of respiratory disorders than sinusitis). Furthermore, the disorders with the higher prototypicality ratings: (1) tended to be recalled earlier in the free-recall task, (2) had the greatest number of attributes (that is, symptoms, signs, pathophysiological characteristics) in common with the other members of a category, and (3) were classified faster and more accurately than the less prototypical ones. The positive correlations between the rated exemplariness of a disorder and its family resemblance score suggest, as Rosch (1978; Rosch and Mervis, 1975) has shown, that disorders become more prototypical to the extent that they are the members with the greatest number of attributes in common with the remaining disorders in the category.

Neither the general practitioners nor the the students listed those disorders encountered most often in the family practice setting. (An exception to this general rule was found in four of the 14 categories.) This finding is in keeping with Rosch's contention that frequency is not the major factor in determining the formation of prototypes (1973; Rosch et al., 1976a; Mervis et al., 1976; Reed, 1972). She adds: "...persistence of the belief that frequency is the basis of typicality may itself be an effect of typicality; it has been demonstrated that subjects overestimate the frequency of typical category

members relative to atypical category members, just as they overestimate the probability of cognitively available and representative events (Kahneman and Tversky, 1973; Tversky and Kahneman, 1973) "(1976, p. 501). Instead, while frequency may play a role in the formation of some prototypes, prototypes most likely arise from the overlapping structure of the attributes of the various members in a category, the family resemblance structure. As was shown, the disorders with the higher prototypicality ratings are those very members that have the most attributes in common with the other disorders in the category. In Rosch's words, "prototypes appear to be just those members of a category that most reflect the redundancy structure of the category as a whole" (1978, p. 37).

While formally defining any category of medical disorders may be a satisfying intellectual exercise, the results of the present study indicate that the actual representation of that information in the long-term memory of pre-clinical medical students and of general practitioners is of a different nature. There is a growing body of empirical evidence in various domains that suggest that knowledge about a category is not represented "by a limited set of singly necessary and jointly sufficient criterial attributes but rather by a loose set of features (imperfectly) correlated with membership in the category" (as summarized by Cantor, Mischel and Schwartz, 1982, p. 47.) This has been shown, for example, for common semantic categories (Rosch et al., 1976a), locative categories (Erreich and Valian, 1979), personality types (Cantor and Mischel, 1979), and social situations (Cantor et al., 1982). Cantor, Smith, French, and Mezzich (1980), in a similar study of the categoriza-

tion of nine psychiatric disorders[1], also found that the internal structure of those categories was better described by the "correlated features" of the prototype view than the "defining features" of the traditional view.

In retrospect, the hunch that gave the incentive to study the organization of the physician's knowledge in long-term memory has found objective support in the notions of prototypes and family resemblance. As emphasized by Rosch, prototypes do not constitute a complete theory of organization of categories but, rather, different models of memory organization or category encoding and retrieval can contain the notion of prototypes (1978)[2]. Prototypes could be used to ask questions about the underlying memory structure as it relates to the problem-solving process. For example: Is there a structural difference in the categories of excellent and weaker diagnosticians? Are prototypes used in initial problem formulations? Are the patients with prototypical disorders (that is, related to readily accessible knowledge) more easily diagnosed than the ones with the peripherial ailments (that is, related

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(1) The nine categories were: functional psychosis, schizophrenia, paranoid schizophrenia, schizo-affective, chronic undifferentiated schizophrenia, affective disorders, manic depressive depressed, manic depressive manic, and involutional melancholia.

(2) For example, "...different theories of semantic memory can contain the notion of prototypes in different fashions (Smith, 1978). Prototypes can be represented either by propositional or image systems... learning prototypicality could be represented in terms of counting attribute frequency (as in Neuman, 1974), in terms of storage of a set of examples to which one later matched the input, or in terms of explicit teaching of the prototypes once prototypicality within a category is established in a culture." (1978, p. 41).

to remote, less accessible knowledge)? To paraphrase Rosch, prototypes do not specify representation or process models but the pervasiveness of results pointing to prototypes in a growing number of studies indicates that prototypes must have a place in the psychological understanding of memory representation and processing. The notion of prototypes will be further discussed in relation to two topics: the differences between expert and novice diagnosticians and the conduct of medical education.

DIFFERENCES BETWEEN EXPERTS AND NOVICES

A number of studies[1] have shown that the key to expert performance is a superior organization of knowledge in long-term memory. Chase and Simon (1973) showed that unlike the novice chess player who perceives and remembers almost every piece on the board as a distinct unit, the expert master player processes the board in terms of meaningful groups of information and is thus able to pack more information into an already limited information processing system. Consequently, the experts made more efficient perceptions and had higher recall performances than the novices. Larkin et al. (1980) conclude that "although a sizable body of knowledge is prerequisite to expert skill, knowledge must be indexed by large numbers of patterns that, on recognition, guide the expert in a fraction of a second to relevant parts of the knowledge store" (p. 1336). The numerous patterns or chunks serve as a useful link between the problem situation and the pertinent knowledge stored in

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(1) For example, Chase and Simon (1973) in chess, Shavelson and Stanton (1975) and Larkin, Mc Dermott, Simon, and Simon (1980) in physics, McKeithen, Reitman, Rueter, and Hirtle (1981) in computer programming, and Voss, Vesonder, and Spilich (1980) in baseball.

long-term memory. Chase and Simon also showed that the skills of the experts were uniquely related to their field of expertise and did not represent a better general strategy for memorization. Norman et al. (1979) reached similar conclusions about medical experts in a preliminary study replicating Chase and Simon's experiment with medical students and practicing physicians.

From the perspective of prototype theory, it could be argued that just as patterns guide the expert to relevant knowledge, so prototypes, because of their representativeness and their many overlapping attributes, also act as a means of accessing the content of a category. The retrieval of prototypical instances could facilitate the recall of other members of the category by making available multiple retrieval pathways between the prototypes and the other category members. There is evidence in the present study of a richer network of knowledge among the experienced physicians as measured by the greater number of interconnections among the disorders in a category. They also had greater associative strength between particular disorders and their corresponding category names as well as quicker access to their knowledge. Based on these results and the current notions of what constitutes expertise, it can be reasonably hypothesized that the cohesiveness of a clinician's categories (within-category structure) may be an important factor to distinguish expert from novice diagnosticians.

This hypothesis is all the more interesting since Cantor et al. (1980) in a study of the diagnostic process of the psychiatrist as a "prototype-matching process", found that the accuracy and confidence of diagnosis increases with the prototypicality of the disease presentation. They conclude: "diagnosis can be made on the basis of

degree of fit between the patient's cluster of symptoms and the prototypes for various different categories" (p. 192). Gale and Marsden (1982) recently showed that physicians, when faced with a clinical problem, rapidly locate in their memories (betweeen 41 and 49 seconds of the onset of a clinical encounter) "an appropriate (or inappropriate, but nonetheless possible) context of information and interpret the clinical information elicited accordingly" (p. 25). From an expert-novice point of view, it could be argued that these initial formulations may arise from expert patterns or in our case, from a scan across prototypes in search of a fit.

In sum, the basic prototypical structure was the same for the medical students and the experienced general practitioners. However, as to expert-novice differences, there are some hints of a more cohesive organization among the physicians. The need for further study will be described in the latter part of this chapter.

MEDICAL EDUCATION

How can one learn to become an expert diagnostician? In accordance with the preceding notions of expertise, two components must be acquired: memorization of a vast amount of information about the coveted field of expertise and creation of access routes to that knowledge base. Larkin et al. (1980) state that textbooks and lectures typically present the materials for knowledge acquisition but rarely explain to the learner when that knowledge is appropriate for a particular problem. In other words, the student is not presented with or not encouraged to create the patterns or indexes that link knowledge with the demands of the problems to be solved later in practice. This shortcoming was also voiced by Barrows and Tamblyn (1980) when they noted the inability of

the entering clinical students to recall subject-based information from earlier years. The students had acquired the detailed descriptions of each disorder but had failed to create the access routes to these descriptions.

In response to the educational problem associated with the traditional medical curricula, the McMaster group (Neufeld and Barrows, 1974; Barrows and Tamblyn, 1980) has advocated a problem-based learning strategy for the acquisition of medical knowledge. They argue that (Barrows and Tamblyn, 1980):

> Information, concepts, and skills learned by the student are put into his memory in association with a problem. This allows the information to be recalled more easily when he faces another problem in which the information is relevant. Recall is constantly reinforced and elaborated by subsequent work with other problems. The student is able to use the problem as a focus for the study of many different subjects, actively integrating this information into a system that can be applied to the problem at hand and to subsequent problems. (p. 13)

An important issue raised by this learning strategy is the selection of learning materials (problems) such that the development of indexing patterns (in our case the prototypes and the family resemblance relationships) can be optimized. Are certain problems better suited than others for effective learning to occur?

Barrows and Tamblyn (1980; Chapter 8, p. 156-162) base their selection process on four criteria: (1) problem frequency, (2) seriousness, (3) important basic science concepts, and (4) often neglected problems. If the curriculum planner is to pay attention to the development of prototypes, accumulated research indicates that problem selection is crucial. Mervis showed that categories are learned more easily and more accurately when the initial exposure is through representative

exemplars (prototypes) as opposed to a range of exemplars (Mervis and Pani, 1980; Hupp and Mervis, 1981; Mervis and Mirman, 1981). An analysis of the problems used in one well estabished problem-based medical curriculum showed that only 31% (4/13) of the problems or diagnoses used during the first year of studies corresponded to one of the top ten disorders listed by the subjects in the present study.[1] The ratio increased to 58% (7/12) during the second year. The initial exposure was thus largely deficient in prototypical materials. Prototypes seem to be insufficiently used and other criteria beside representativeness are applied.

Although problem-based learning offers a more relevant means of presenting the materials to the learner, Larkin et al. (1980) suggest, based in part on the development of computer-based learning systems (for example, Neves, 1978), that it may not be a sufficient condition to acquire expert knowledge. Problem-based learning has to be more than simply accumulating problems or examples of problem solutions. They add that the patterns of the experts can be developed most effectively by reflecting upon why, in a certain situation, a particular solution did or did not work. For example: In a patient suffering from diabetes for many years and complaining of nausea, vomiting and abdominal pain, why is it appropriate to think not only of diabetic acidosis but also of renal insufficiency? Barrows and Tamblyn (1980) urge the students "to review their work with the problem and take stock of what has been learned and its significance" (p. 103). The question still remains as

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(1) Based on the positive correlations obtained between prototypicality ratings and item outputs (.83 and .85 for the students and physicians respectively), it is assumed here that the top items listed in a category correspond in general to the prototypes.

to the effectiveness of this leaning strategy for the acquisition of prototypes.

Also related to problem selection is the importance of intermediate-level categories for concept learning. Research increasingly suggests that concept learning does not proceed from the most general to the most differentiated, nor from the most specific to the most general (reported in Wickelgren, 1981 p. 35-36; see also: Brown, 1958, and Rosch et al., 1976a). Instead concepts are initially learned at an intermediate level comparable to Rosch's basic-level objects (for example, chair instead of furniture (too general) or footstool (too specific)). Wickelgren (1981) in his recent review of learning and memory summarized the implications of basic-level concepts for learning in the following manner:

> The high degree of example similarity means extensive strength generalization in the integrative learning of separate examples, which, in effect, increases the frequency of pairing each attribute node with the concept node. On the average, the basic-level concepts are those where the two factors contributing to associative strength, example frequency and example similarity, typically hit the maximum in their combined effect on speed of concept learning. (p. 35 and 36)

Rosch and Mervis (1975) state: "Therefore category membership is most obvious for the highly representative exemplars, and generalization based on similarity to these will be the most accurate" (p. 100). Furthermore, basic-level categories is "the level at which categories maximize within-category similarity relative to between-category similarity" (Mervis and Rosch, 1981, p. 92). The educational implications of these principles would be to encourage the learner to master initially the basic-level concepts (for example, angina pectoris as opposed to

ischemic disorders (too general) or Gairdner's disease (too specific)) and to acquire subsequent materials in relation to the highly representative, intermediate-level exemplars.

The lack of prototype-based materials was also noted by Cantor et al. (1980) in psychiatry. However, there is cause for optimism since they found a shift in the presentation of the materials in the latest edition of the APA's diagnostic manual of mental disorders that is compatible with a prototypical view. They conclude:

> Diagnostic criteria are now presented as prototypes -larger sets of correlated features rather than selected defining ones; guidelines for diagnosis also emphasize the potential heterogeneity of the symptoms of like-diagnosed patients. Moreover, the potential for overlap in clinical features across different diagnostic categories is underscored by sections on differential diagnosis. From the perspective of the prototype view, these changes are important, because they help to emphasize, rather than obscure, the probabilistic nature of diagnostic categorizations. On the basis of the new manual, clinicians can now be trained to expect heterogeneity among patients and to recognize the probabilistic nature of diagnostic categorizations. (p. 190 and 192)

In summary, choosing problems for problem-based curriculum, or any other learning for that matter, is crucial and other criteria besides representativeness seem to be used. Recent research suggests that initial exposure to the more prototypical instances in a category as well as to intermediate-level categories may enhance learning.

The references to similarity judgments in the preceding pages brings out yet another implication of prototypes for medical diagnosis. Physicians typically tend to confirm diagnostic hypotheses (that is, add up the pros) rather than to rule them out (Barrows et al., 1978; Elstein and Bordage, 1979). Tversky (1977) argued that the relative importance

given to the common and distinctive attributes in a category may differ depending on whether the task consists of assessing similarity as opposed to assessing difference. He concluded: "...people attend more to the common features in judgments of similarity than in judgments of difference" (p. 340). The prototypes represent an efficient means to assess similarity and could serve as a "representative heuristic" (Tversky and Kahneman, 1974) by which physicians could decide whether or not a clinical syndrome belongs to a particular category by judging the similarity between the attributes of the patients and the attributes of the category. Instead of searching the entire content of a category, the clinician can simply attend to the prototypes because they are themselves the members with the greatest similarity (that is, attributes in common) to all the other members in the category. On the basis of the prototypes, the clinician could decide whether the category is worth investigating any further and, if so, then could proceed from the best to the least exemplary members along the many family-resemblance pathways. Gale and Marsden's findings presented earlier suggest that this process occurs very early in the clinical encounter.

FUTURE RESEARCH

The main theme of this general discussion has been that a prototypical notion of the mental categorization of medical knowledge has many potential implications for learning to become an expert diagnostician and for the process of making a diagnosis. Let us assume that (1) diagnostic expertise involves the creation of numerous indexing schemes that link the vast content of the clinician's medical knowledge with the demands of the clinical problems to be solved, and that (2) what we know

about prototypes and prototype formation is directly applicable to the conduct of medical education and the process of medical diagnosis. Then it follows that it is essential to give due consideration to the following issues:

- that diagnostic expertise involves a vast amount of medical knowledge that is indexed by prototypical exemplars, and that those exemplars evolve from the correlated structure of the attributes in a category;

- that effective learning of diagnostic expertise comes from not only the accumulation of examples of problem situations or solutions but most likely from reviewing why certain solutions were or were not most effective. The constant remodeling of past experiences creates the numerous indexes and overlapping features of the prototypes in a category, the family-resemblance structure;

- that choosing the proper problem materials for learning is crucial: learning will be maximized by giving the student an initial exposure to the most representative members of a category (the prototypes) rather than to a full range of disorders, and that intermediate level problems or diagnoses will also foster maximal integration of learning materials;

- that in viewing the diagnostic process as a prototype-matching process, the prototypes offer an efficient means of searching the content of a number of potentially relevant categories of medical knowledge given the problem at hand.

The speculations put forward in this chapter inevitably raise the issue of future research. The positive results obtained in the present study in favor of prototypes, as well as those of Cantor et al. (1980) in psychiatry, constitute sufficient evidence to warrant the pursuit of further investigations. Three avenues are especially germane; these examine either the differences between expert and novice clinicians in a diagnostic situation or the issue of effective medical education.

STIMULI

Clusters of category members which can reasonably be expected to range from very good to very poor members (exemplars) of their respective categories were needed to test the hypothesis of prototypicality. Following Rosch's method (1973; Rosch, et al., 1976b), six instances from each of the 14 categories tabulated in Experiment - 1 were selected. The six instances were chosen such that they would approximate the full range of frequency distribution, that is, two frequently mentioned disorders, two moderate ones, and two infrequent ones (mentioned only one or twice). Within a given range, for example the moderate ones, members were chosen randomly. In addition to the six instances just described, two other members were included: the top or most frequently mentioned member and a member randomly selected from a totally different category. It was expected that this latter instance would rate at or near the lowest point on the rating scale as opposed to the former rating near the highest point. Although separate lists were drawn for the students and the physicians, a special procedure was applied to allow for a comparison between the two samples. First, the random selection process was applied to the student data. Whenever possible, the same item or a very close one (for example, siderosis and asbestosis) was included in the physician list because it was common to both samples within the same frequency range. Otherwise, a new and randomly selected item was included in the physician list. The 112 items used for the students and the physicians are presented later in Tables 11 and 12 along with the obtained ratings.

INSTRUCTIONS

Using a double-anchored scale (the two extremes given), the subjects were asked to rate on a 7-point scale the extent to which a particular disorder was a good example of a member of a given category. The experiment was conducted in French. A modified version of Rosch and Mervis' instruction set (1975) was used[1]:

When someone mentions the name of a category used in medicine, a certain number of examples comes to your mind. The following pages contain the names of 14 medical categories, one per page. There are 8 instances (disease, pathologies, problems) listed under the name of each category. You are asked to rate how good an example of a category these various instances of the category are. For each category, please proceed as follows:

1- Read the name of the category.

2- Read the name of an instance.

3- Decide on the 7-point scale to what extent you think that instance is a good example of the proposed category. A 7 means you feel the instance is a very good example of a member of that category whereas a 1 means you feel the instance is not a member at all. Express your judgment by circling the appropriate number on the scale to the right of each instance. Use the various numbers on the scale to express varying levels of representativeness. If an instance is totally unknown to you, circle a 1 denoting no relationship.

4- Repeat the preceding steps for each one of the 8 instances. You must make a choice for each instance.

5- Repeat the preceding steps for each one of the 14 categories. There is no time limit to complete the task.

Here is an example:

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(1) The actual French instructions are available upon request.

Category name: FURNITURE

Instance:	Not associated						Excellent example
Chair	1	2	3	4	5	6	(7)
Telephone	1	(2)	3	4	5	6	7
Stereo	1	2	3	4	(5)	6	7
Canoe	(1)	2	3	4	5	6	7
Stool	1	2	3	4	5	(6)	7
Trash can	1	2	3	(4)	5	6	7
Couch	1	2	3	4	5	6	(7)
Ash tray	1	2	(3)	4	5	6	7

In the example, the subject judged that the instances "Chair" and "Couch" were excellent examples of the category "Furniture" as indicated by the circled number 7. On the other hand, the subject saw no association between the instance "Canoe" and the category "Furniture" as indicated by the circled number 1. The subject used the other numbers on the scale to express various intermediate levels of representativeness such as the numbers 5 and 3 for the instances "Stereo" and "Ash tray".

Do not worry about why you think that something is or is not a good example of a category. And do not worry about what others may think. Just mark it the way it spontaneously comes to your mind.

PROCEDURE

Each of the 14 categories and their respective eight instances were assembled into a booklet along with a demographic questionnaire and a set of instructions. Each subject received a booklet, answered the questionnaire, read the instructions, and completed the rating task. Subjects were tested individually or in groups ranging in size from two to eight persons. An experimental session lasted about 15 minutes.

To minimize a sequential effect of the responses, the eight instances within each category were presented in a random order for each category. Also, two different random sequences of the 14 categories were used for the student sample; an oversight in the photocopying process prevented from doing the same with the physicians. Each

A first avenue of interest is whether it can be more clearly shown that prototypes are better differentiated among expert diagnosticians than novices. McKeithen et al. (1981) in their study of computer programmers showed that differences in knowledge organization did accompany skill-level differences (p. 307); while the depth of organization did not seem to increase with skill level (p. 319), the experts had remarkably similar organizations clustered around specialized programming languages (p. 323). A similar finding is suggested in the present study by the higher levels of commonality among the physicians as opposed to the students. A more systematic investigation into the mental organization of expert and novice diagnosticians as it pertains to diagnostic problem solving is warranted. Like McKeithen, a Chase and Simon-like experiment could be conducted followed by a detailed analysis of the subjects' prototypical structure (for example, richness of the family-resemblance relationships and speed and accuracy of processing).

Basic-level categories could constitute a second avenue of future research. The importance of basic-level instances is related both to learning and diagnostic problem solving. A first topic of investigation could be to determine which types of taxonomies of medical knowledge are used in clinical practice as well as the various levels of abstraction that compose them. For example, do physicians think mostly in terms of symptomatology or problems, diseases or body systems, or some combination of these? Rosch et al. (1976a) as well as Dougherty (1978) have shown that basic levels can vary as a function of both culture and domain and level of expertise. Again, it could be hypothesized that differences between experts and novices could be due to differences in the level of abstraction at which the two groups function.

A third avenue of future research could focus on the role of basic-level prototypes as a means of enhancing the acquisition of knowledge. As previously described, concept learning was facilitated by initial exposure to highly prototypical basic-level instances. The effectiveness of these two factors, as well as other more traditional ones, could be tested for medical concepts by using a multi-comparison experimental design. Based on past research in other domains (for example, with basic object categories, Mervis and Pani (1980) and Rosch et al. (1976a)), it would not be surprising to find that initial acquisition of such prototypical materials does produce greater skills. However, special attention should be given to the particular educational aim being pursued. For example, although it may be shown that initial exposure to prototypes enhances the acquisition of category typicality, a different strategy may be more effective when the goal is to learn atypicality as may be the case in medical specialties.

CHAPTER VIII

CONCLUSION

The mental categorization of medical knowledge can be conceived of in two ways: as rule-defined structures derived from a criterion and expressed within definite boundaries inside which all members have equal and full membership, or in terms of the category's best examples or clearest cases with other members tending toward an order from better to poorer instances. Rosch refers to the clear cases as the prototypes. The purpose of the present study was twofold: (1) to determine whether the notion of prototypes as developed by Rosch and co-workers was applicable to the structure of selected categories of medical disorders as stored in physicians' long-term memory, and (2) to describe the influence of clinical experience on those structures. Four experiments were conducted with 100 pre-clinical medical students and 77 experienced general practitioners to establish a converging sequence of evidence concerning the internal structure of 14 broad categories of medical disorders.

There were three basic and converging findings from the present series of experiments.

First, the striking structural feature of the 14 categories, both for the students and the physicians, was not in the presence of criterial attributes which defined the category and gave its members full and equal membership, but rather in the presence of disorders that were per-

ceived as having various degrees of membership and of many attributes common to some but not all the category members. The disorders within each category were linked together by means of a network of overlapping features, the family resemblance relationship, rather than by necessary and sufficient defining features.

Both the students and the physicians made reliable judgments about the degrees of exemplariness (prototypicality) of the various disorders in each category. These differential ratings suggest that from a psychological perspective, the disorders in a category were not all viewed as equally representative of the category. Following the rule-defined, deterministic view of categorization, once a member shares the criterion, it is a full and equal member of the category. The results obtained in the present study failed to support both of these assumptions. The disorders with the higher prototypicality ratings tended to be recalled earlier in the free-recall task and had the greatest number of attributes in common with the other disorders in the category. The positive correlations between the rated exemplariness of a disorder and its family resemblance score suggest, as argued and demonstrated by Rosch and Mervis (1975) for categories of common objects, that disorders become more prototypical to the extent that they are the members with the greatest number of attributes in common with the remaining disorders in the category. The fact that overall there was but a 55% overlap between the most frequently listed responses and the most frequent disorders in actual general practice also adds to the argument that prototypes are formed not only on the basis of frequency of occurence but also from the overlapping structure of the attributes in each category.

Second, prototypicality predicted category processing as measured by the subjects' mean response time to category membership statements. It took less time, both for the students and the physicians, to make judgments about the category membership of central disorders (high prototypicality ratings) as opposed to peripherial ones. Furthermore, while the judgments were virtually error-free for the central members, many more errors were made for the peripherial ones. These results suggest that the further away one is from the prototypical instances, the less obvious it is that an instance does belong to the category, although it was listed as such initially.

Third, the overall internal structure of the categories of the students and the physicians were similar. Both made reliable prototypicality ratings and exhibited the characteristic family resemblance relationship related to prototypes. However, although there was a high degree of similarity in the overall content of the categories as listed by the students and the physicians, the experienced general practitioners had a richer and more readily accessible network of knowledge than the novice medical students. The fact that the physicians used a narrower range of points on the rating scale and responded faster to category membership statements both suggest that the associative strength between a disorder and its category label is stronger for the physicians than the students. The higher family resemblance scores among the physicians indicate on the other hand that the disorders in the physicians' categories have more explicit ties among each other; the number of overlapping attributes is greater.

The evidence gathered in each of the four experiments all converge on the conclusion that the internal structure of the 14 categories

of medical disorders is better represented by the prototypical notions of categorization than by the traditional rule-defined deterministic view. Cantor et al. (1980) also reached a similar conclusion for nine categories of mental disorders. A number of potential implications for the conduct of medical education were raised. These implications are directly related to the two questions put forward at the beginning of the study: namely, How is medical knowledge organized in the physicians' long-term memory, and are different structures related to different learning outcomes or clinical performances?

From an expert-novice point of view, the differentiating factor between the two levels of expertise is not only in terms of the large amount of knowledge that the experts have acquired but also in the numerous access routes or indexes they have which guide them rapidly to relevant knowledge (see Larkin et al., 1980). Medical textbooks and much classroom teaching abound in presenting detailed lists of disorders, features, and therapeutic actions to the medical students but most often fail to provide a categorization scheme that is best suited for their retrieval in a clinical problem-solving situation. It was hypothesized that prototypes, with their category representativeness features and their overlapping attributes, may well serve as an effective indexing scheme for the clinician's knowledge. This hypothesis is all the more interesting in that Cantor et al. (1980) found that both the accuracy and confidence of diagnosis increases with the prototypicality of the disease presentation. If educational planners are to emphasize the correlational structure of the attributes in a category as is the case with prototypes, then special care should be taken in the selection of the materials to be used for learning (be they disorders,

problems, diagnoses, or complaints). Based on available findings in various other domains, initial exposure to the more prototypical instances as well as to intermediate level categories may enhance learning. The positive results obtained in the present study, when combined with other findings about prototypes in various other domains, have led to a host of interesting speculations from which a number of future research avenues are proposed.

APPENDICES

APPENDIX A

OUTLINE OF THE UNDERGRADUATE CURRICULUM AT LAVAL UNIVERSITY MEDICAL SCHOOL (1979-80)

APPENDIX A

Outline of the undergraduate curriculum at Laval University Medical School (1979-80). *

Year one

Fall (12.5 credits)	Gross anatomy Biochemistry Cell biology General histology
Winter (18.5 credits)	Human biology I- Blood, circulation and respiration II- Nutrition, digestion III- Kidneys, urinary tract and electrolytes Histology and embryology Functional exploration and pathophysiology Human nutrition Psycho-social aspects of medical practice Microbiology

Year two

Fall (12.5 credits)	Human biology IV- Endocrinology Clinical methods Pharmacology and toxicology I Problems in health care Immunology
Winter (20.5 credits)	General pathology I Pharmacology and toxicology II Infectious disorders Clinical methods Musculoskeletal system Nervous system Problems in health care

* The complete program for the first three years contains a total of 109 trimester credits (1 credit = 45 hours of work over 15 weeks of which 15 hours are in-class activities) including 78 required credits, 16 electives and 15 clinical session credits.

Appendix A continued

Year three

Fall (14 credits)	General pathology II Disorders of the cardio-respiratory systems Disorders of the blood Disorders of the gastrointestinal system Disorders of the kidneys and urinary tract Disorders of the endocrine and reproductive systems
Winter (15 credits)	Clinical session : in-hospital introduction to clinical methods

APPENDIX B

BASIC DATA FROM EXPERIMENT-1: CATEGORY NORMS

APPENDIX B-1

RESPIRATORY DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Pneumonie	55	38	17
2. Asthme	51	35	16
3. Emphysème	50	32	18
4. Pneumothorax	36	22	14
5. Bronchite chronique	33	19	14
6. T.B.	32	24	8
7. Néoplasie pulmonaire	29	17	12
8. Bronchiectasie	29	23	6
9. Bronchite	27	16	11
10. Pleurésie	25	19	6
11. Bronchopneumonie	22	17	5
12. Amiantose	21	15	6
13. Sarcoïdose	19	12	7
14. O.A.P.	19	15	4
15. Abcès pulmonaire	17	17	5
16. Atélectasie	16	14	2
17. Laryngite	15	7	8
18. Oat cell	15	8	7
19. Silicose	15	13	2
20. Epanchement pleural	15	13	2
21. Poumon du fermier	13	13	0
22. Alvéolite	13	5	8
23. Trachéite	12	3	9
24. Pharyngite	12	5	7
25. Embolie pulmonaire	11	11	0
26. Rhinite	9	2	7
27. Bronchite aigue	9	3	6
28. Grippe	9	6	3
29. I.V.R.S.	8	1	7
30. Sinusite	8	3	5
31. Hémothorax	8	5	3
32. Fibrose pulmonaire	8	6	2
33. Insuffisance pulmonaire	7	5	2
34. Empyème	5	5	0
35. Bérylliose	5	5	0
36. Sidérose	5	5	0

APPENDIX B-2

CARDIOVASCULAR DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Infarctus du myocarde	59	41	18
2. Angine de poitrine	56	39	17
3. Sténose mitrale	35	27	8
4. Sténose aortique	33	25	8
5. Insuffisance cardiaque	33	21	12
6. H.T.A.	30	21	9
7. Insuffisance mitrale	23	16	7
8. Artérisclérose	22	14	8
9. Embolie	21	16	5
10. C.I.V.	21	15	6
11. Anévrisme aortique	21	11	10
12. C.I.A.	20	14	6
13. Thrombose	19	15	4
14. Péricardite	19	14	5
15. Sténose pulmonaire	19	14	5
16. Insuffisance aortique	18	13	5
17. Maladie de Buerger	18	7	11
18. Athérosclérose	17	12	5
19. R.A.A.	16	15	1
20. Phlébite	15	9	6
21. Sténose tricuspidienne	12	12	0
22. Endocardite	12	9	3
23. Coarctation	12	9	2
24. Arythmie	12	8	4
25. Maladie de Raynaud	10	9	1
26. Myocardite	10	7	3
27. Varices	10	5	5
28. Bloc de branches	9	6	3
29. Tétralogie de Fallot	9	5	4
30. Hypercholestérolémie	8	8	0
31. Insuffisance tricuspidienne	8	8	0
32. Insuffisance pulmonaire	8	7	1
33. Insuffisance cardiaque gauche	8	5	3
34. Artérite	8	5	3
35. Thrombophlébite	7	7	0
36. Canal aortique	7	7	0
37. Insuffisance cardiaque droite	7	5	2
38. Vasculite	7	5	2
39. Insuffisance coronarienne	6	0	6
40. Cardiopathie idiopathique	5	0	5
41. Insuffisance vasculaire	5	5	0
42. Fibrillation ventriculaire	5	5	0

APPENDIX B-3

GENITOURINARY DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Pyélonéphrite	38	22	16
2. Lithiase urinaire	36	21	15
3. Uréthrite	35	21	14
4. Cystite	34	17	17
5. Vaginite	26	18	8
6. Gonorrhée	25	20	5
7. Glomérulonéphrite	25	18	7
8. Prostatite	25	15	10
9. Salpingite	22	15	7
10. H.B.P.	22	15	7
11. Syphilis	21	17	4
12. Epididymite	16	9	7
13. Kyste ovarien	15	7	8
14. Hydronéphrose	12	8	4
15. Néoplasie de la vessie	12	7	5
16. Néoplasie de la prostate	11	9	2
17. Tumeur de Grawitz	11	8	3
18. Infection urinaire	11	5	6
19. Tumeur de Wilms	10	6	4
20. Orchite	9	4	5
21. Néoplasie du col utérin	8	6	2
22. Vulvite	8	6	2
23. Balanite	7	5	2
24. Endométrite	7	2	5
25. Impuissance	7	7	0
26. Vessie neurogène	6	5	1
27. Phimosis	6	6	0
28. Ovarite-oophorite	5	5	0
29. Calcul uréthral	5	0	5
30. Dysménorrhée	5	0	5

APPENDIX B-4

GASTROINTESTINAL DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Colite ulcéreuse	42	28	14
2. Maladie de Crohn	38	27	11
3. Ulcère gastrique	32	22	10
4. Ulcère duodénal	30	21	9
5. Gastrite	30	17	13
6. Pancréatite	28	18	10
7. Appendicite	26	16	10
8. Néoplasie de l'estomac	25	17	8
9. Néoplasie du colon	25	17	8
10. Hémorroïdes	24	14	10
11. Oésophagite	22	9	13
12. Diverticulite	21	9	12
13. Cholécystite	19	12	7
14. Diverticules	19	7	12
15. Gastroentérite	16	8	8
16. Néoplasie de l'oésophage	15	9	6
17. Cholélithiase	15	7	8
18. Polypes	14	9	5
19. Ulcère	12	6	6
20. Néoplasie du rectum	12	5	7
21. Obstruction	11	11	0
22. Ulcère peptique	11	6	5
23. Iléite régionale	11	6	5
24. Volvulus	11	5	6
25. Achalasie	10	9	1
26. Hernie hiatale	10	3	7
27. Hépatite	9	7	2
28. Néoplasie du grêle	9	6	3
29. Colite granulomateuse	9	5	4
30. Colon irritable	9	5	4
31. Diverticule de Meckel	9	4	5
32. Spasme oésophagien	8	8	0
33. Malabsorption	8	5	3
34. Néoplasie	7	6	1
35. Cirrhose	6	6	0
36. Iléus paralytique	5	5	0
37. Maladie de Hirschsprung	5	5	0

APPENDIX B-5

ENDOCRINE DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Hyperthyroïdie	57	39	18
2. Hypothyroïdie	56	35	12
3. Diabète sucré	49	31	18
4. Maladie de Cushing	43	31	12
5. Maladie d'Addison	37	26	11
6. Hypopituitarisme	29	23	6
7. Acromégalie	21	17	4
8. Hyperaldostéronisme	19	14	5
9. Phéochromocytome	18	15	3
10. Syndrome de Sheehan	14	6	8
11. Insulinome	13	10	3
12. Hypogonadisme	13	6	7
13. Hyperparathyroïdie	12	8	4
14. Thyroïdite d'Hashimoto	12	7	5
15. Hypoparathyroïdie	11	8	3
16. Thyroïdite	9	6	3
17. Diabète insipide	8	5	3
18. Goître	7	0	7
19. Gigantisme	6	0	6
20. Hermaphrodisme	5	5	0
21. Insuffisance surrénalienne	5	0	5
22. Tumeur hypophysaire	5	0	5

APPENDIX B-6

MUSCULOSKELETAL DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Fractures	45	29	16
2. Arthrite	32	23	9
3. Entorse	31	20	11
4. Tendinite	27	10	17
5. Arthrose	25	19	6
6. Bursite	24	9	15
7. Dystrophie musculaire	17	11	6
8. Luxation	16	12	4
9. Myasthénie grave	15	10	5
10. Hernie discale	14	6	8
11. Arthrite rhumatoïde	14	5	9
12. Paralysie	12	12	0
13. Ostéoporose	12	10	2
14. Ostéomalacie	12	10	2
15. Scoliose	11	8	3
16. Cyphose	10	8	2
17. Maladie de Paget	9	7	2
18. Etirement musculaire	8	7	1
19. Déchirure ligametaire	8	6	2
20. Goutte	8	3	5
21. Ostéosarcome	7	7	0
22. Spondylite ankylosante	7	7	0
23. Charley Horse	7	6	1
24. Lordose	7	6	1
25. Rachitisme	7	6	1
26. Ostéomyélite	7	5	2
27. Arthrite psoriasique	7	0	7
28. Myosite	7	2	5
29. Néoplasie	6	6	0
30. R.A.A.	6	5	1
31. Pied bot	6	5	1
32. Contusion	6	0	6
33. Capsulite	6	1	5
34. Rhumatisme	5	5	0
35. Crampe musculaire	5	5	0
36. Subluxation	5	5	0

APPENDIX B-7

NEUROLOGICAL DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Sclérose en plaques	43	26	17
2. Maladie de Guillain-Barré	20	18	2
3. Paralysie	20	17	3
4. Hémiplégie	20	14	6
5. Maladie de Parkinson	18	14	4
6. A.C.V.	15	8	7
7. Méningite	15	7	8
8. Thrombose cérébrale	13	1	12
9. Polyomyélite	12	10	2
10. Epilepsie	12	5	7
11. Migraine	12	2	10
12. Paraplégie	11	10	1
13. Tumeur cérébrale	10	3	7
14. Sclérose lat. amyotrophique	9	6	3
15. Ataxie de Friedrich	9	6	3
16. Névrite	9	5	4
17. Hémorragie	9	4	5
18. Céphalée de tension	8	0	8
19. Embolie cérébrale	8	2	6
20. Paresthésie	7	7	0
21. H.I.C.	6	6	0
22. Quadraplégie	6	5	1
23. Céphalée	6	5	1
24. Vertiges	6	5	1
25. Polynévrite	6	5	1
26. Chorée de Huntington	5	5	0
27. Hématome sous dural	5	0	5

APPENDIX B-8

HEMATOLOGICAL DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Anémie	33	21	12
2. Leucémie	29	17	12
3. Anémie pernicieuse(Biermer)	29	17	12
4. Maladie de Hodgkin	25	16	9
5. Lymphome (non-Hodg.)	24	19	5
6. Polyglobulie vraie	24	17	7
7. Anemie ferriprive	23	12	11
8. Hémophilie	22	17	5
9. Leucémie myéloïde chronique	21	18	3
10. Leucémie myéloïde aigue	15	10	5
11. Myélome multiple	13	11	2
12. Hémorragie	12	10	2
13. Thrombocytose	12	9	3
14. Leucémie lymphoïde chronique	12	9	3
15. Anémie hémolytique	11	7	4
16. Anémie mégaloblastique	10	6	4
17. Leucémie lymphoïde	9	6	3
18. Drépanocytose	9	9	0
19. Thrombose	7	7	0
20. Mononucléose infectieuse	7	2	5
21. Leucémie lymphoïde aigue	6	6	0
22. Macroglobulinémie	6	5	1

APPENDIX B-9

INFECTIOUS DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Pneumonie	41	24	17
2. Pharyngite	34	19	15
3. Gonorrhée	27	20	7
4. Amygdalite	27	9	18
5. Syphilis	25	20	5
6. Méningite	23	14	9
7. Otite	22	11	11
8. Cystite	21	9	12
9. T.B.	19	15	4
10. Laryngite	19	14	5
11. Vaginite	19	10	9
12. Bronchite	19	8	11
13. Pyélonéphrite	19	8	11
14. Abcès	18	10	8
15. Grippe	17	13	4
16. Sinusite	17	5	12
17. Salmonellose	17	15	2
18. Salpingite	15	8	7
19. Appendicite	15	7	8
20. Septicémie	14	13	1
21. Rougeole	14	12	2
22. Uréthrite	13	6	7
23. Hépatite	12	12	0
24. Bronchopneumonie	12	10	2
25. Rhinite	12	7	5
26. Prostatite	12	1	11
27. Rubéole	11	9	2
28. Cholécystite	11	6	5
29. Varicelle	10	9	1
30. Gastroentérite	10	7	3
31. Infection urinaire	10	5	5
32. Diphtérie	9	9	0
33. Oreillons	8	8	0
34. Bactériémie	8	7	1
35. Otite moyenne	8	1	7
36. Orchite	8	6	2
37. Coqueluche	7	7	0
38. Scarlatine	7	7	0
39. Endocardite	7	7	0
40. Gangrène	7	6	1
41. Ostéomyélite	7	6	1
42. Endométrite	6	0	6
43. Panaris	6	1	5
44. Candidose	5	5	0
45. Malaria	5	5	0

APPENDIX B-10

NEOPLASTIC DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Néoplasie de l'estomac	29	19	10
2. Leucémie	20	10	10
3. Adénocarcinome	19	14	5
4. Néoplasie du colon	18	13	5
5. Néoplasie du poumon	18	12	6
6. Maladie de Hodgkin	18	6	12
7. Néoplasie des seins	17	12	5
8. Oat cell	17	10	7
9. Néoplasie du pancréas	17	9	8
10. Mélanome	16	10	6
11. Néoplasie du rectum	16	9	7
12. Tumeur de Grawitz	16	9	7
13. Néoplasie de l'oésophage	15	11	4
14. Lymphome	14	8	6
15. Néoplasie du col utérin	13	11	2
16. Néoplasie de l'utérus	13	7	6
17. Tumeur de Wilms	12	10	2
18. Ostéosarcome	11	6	5
19. Néoplasie du foie	10	7	3
20. Néoplasie de la prostate	10	7	3
21. Néoplasie des os	10	6	4
22. Hépatome	9	4	6
23. Néoplasie de la vessie	9	7	2
24. Rhabdomyosarcome	8	7	1
25. Néoplasie de la langue	8	5	3
26. Adénocarcinome des seins	8	3	5
27. Néoplasie de la peau	8	3	5
28. Néoplasie du grêle	7	6	1
29. Néoplasie de l'anus	7	7	0
30. Néoplasie de l'intestin	7	5	2
31. Léiomyosarcome	6	6	0
32. Epithélioma	6	6	0
33. Rétinosarcome	6	6	0
34. Lymphosarcome	6	5	1
35. Néoplasie épidermoïde	5	5	0
36. Sarcome	5	5	0
37. Néoplasie du larynx	5	0	5

APPENDIX B-11

INFLAMMATORY DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Arthrite rhumatoïde	27	13	14
2. Arthrite	26	20	6
3. Bursite	20	5	15
4. Otite	18	15	3
5. Pharyngite	18	13	5
6. Appendicite	16	12	4
7. Conjonctivite	16	11	5
8. Tendinite	16	4	12
9. Maladie de Crohn	15	8	7
10. Pancréatite	14	13	1
11. R.A.A.	14	10	4
12. Colite Ulcéreuse	14	9	5
13. Cholécystite	13	10	3
14. Gastrite	13	10	3
15. Péricardite	12	11	1
16. Péritonite	10	9	1
17. Laryngite	10	9	1
18. Méningite	10	9	1
19. Hépatite	10	9	1
20. Lupus érythémateux	10	5	5
21. Rhinite	9	7	2
22. Bronchite	9	7	2
23. Pneumonie	8	7	1
24. Amygdalite	8	6	2
25. Goutte	8	2	6
26. Rhumatisme	7	7	0
27. Uvéite	7	6	1
28. Sinusite	7	6	1
29. Synovite	7	5	2
30. Pleurésie	6	6	0
31. Salpingite	6	6	0
32. Endocardite	6	6	0
33. Rétinite	5	5	0
34. Artérite	5	5	0
35. Périartérite noueuse	5	5	0
36. Diverticulite	5	5	0

APPENDIX B-11

INFLAMMATORY DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Arthrite rhumatoïde	27	13	14
2. Arthrite	26	20	6
3. Bursite	20	5	15
4. Otite	18	15	3
5. Pharyngite	18	13	5
6. Appendicite	16	12	4
7. Conjonctivite	16	11	5
8. Tendinite	16	4	12
9. Maladie de Crohn	15	8	7
10. Pancréatite	14	13	1
11. R.A.A.	14	10	4
12. Colite Ulcéreuse	14	9	5
13. Cholécystite	13	10	3
14. Gastrite	13	10	3
15. Péricardite	12	11	1
16. Péritonite	10	9	1
17. Laryngite	10	9	1
18. Méningite	10	9	1
19. Hépatite	10	9	1
20. Lupus érythémateux	10	5	5
21. Rhinite	9	7	2
22. Bronchite	9	7	2
23. Pneumonie	8	7	1
24. Amygdalite	8	6	2
25. Goutte	8	2	6
26. Rhumatisme	7	7	0
27. Uvéite	7	6	1
28. Sinusite	7	6	1
29. Synovite	7	5	2
30. Pleurésie	6	6	0
31. Salpingite	6	6	0
32. Endocardite	6	6	0
33. Rétinite	5	5	0
34. Artérite	5	5	0
35. Périartérite noueuse	5	5	0
36. Diverticulite	5	5	0

APPENDIX B-12

DYSPNEA-RELATED DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Emphysème	49	34	15
2. Asthme	47	31	16
3. Insuffisance cardiaque	41	28	13
4. Pneumonie	30	18	13
5. Bronchite chronique	30	20	10
6. O.A.P.	26	19	7
7. Embolie pulmonaire	24	14	10
8. Pneumothorax	23	10	13
9. Bronchite	20	14	6
10. Néoplasie du poumon	20	12	8
11. Atélectasie	11	10	1
12. Pleurésie	11	7	4
13. Anémie	11	4	7
14. T.B.	11	4	7
15. Oédème pulmonaire	10	9	1
16. Angine de poitrine	10	6	4
17. Infarctus du myocarde	9	7	2
18. Fracture de côtes	9	6	3
19. Hémothorax	8	3	5
20. Amiantose	8	3	5
21. Infection respiratoire	7	7	0
22. Bronchiectasie	6	5	1
23. Laryngite	6	1	5
24. Sténose mitrale	5	5	0

APPENDIX B-13

ABDOMINAL PAIN-RELATED DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Appendicite	43	34	19
2. Pancréatite	42	25	17
3. Cholécystite	39	23	16
4. Néphrolithiase	26	13	13
5. Ulcère duodénal	24	14	10
6. Péritonite	22	20	2
7. Cholélithiase	21	8	13
8. Maladie de Crohn	20	13	7
9. Hépatite	19	16	3
10. Salpingite	18	11	7
11. Ulcère gastrique	18	9	9
12. Colite ulcéreuse	18	13	5
13. Diverticulite	17	4	13
14. Gastrite	17	8	9
15. Obstruction	16	15	1
16. Volvulus	15	10	5
17. Néoplasie du colon	14	10	4
18. Pyélonéphrite	13	6	7
19. Cystite	12	6	6
20. Ulcère peptique	12	6	6
21. Diverticules	10	9	1
22. Perforation	9	7	2
23. Dysménorrhée	9	6	3
24. Diverticule de Meckel	8	2	6
25. Ulcère	8	7	1
26. Néoplasie du pancréas	8	7	1
27. Néoplasie de l'estomac	8	5	3
28. Adénite mésentérique	8	0	8
29. Kyste ovarien	7	2	5
30. Infection urinaire	7	2	5
31. Endométrite	6	1	5
32. Constipation	6	0	6
33. Ileus paralytique	5	5	0
34. Infarctus	5	5	0

APPENDIX B-14

JOINT PAIN-RELATED DISORDERS

	TF	$TF_{students}$	$TF_{physicians}$
1. Arthrose	38	28	10
2. Arthrite rhumatoïde	34	18	16
3. Déchirure méniscale	31	20	11
4. Arthrite	28	20	8
5. Fracture	26	18	8
6. R.A.A.	24	17	7
7. Luxation	23	19	4
8. Entorse	23	15	8
9. Goutte	18	8	10
10. Synovite	17	13	4
11. Bursite	14	10	4
12. Hémarthrose	13	9	4
13. Déchirure ligamentaire	11	9	2
14. Rhumatisme	10	8	2
15. Ostéoarthrite	10	4	6
16. Arthrite psoriasique	10	2	8
17. Spondylite ankylosante	9	7	2
18. Tendinite	8	6	2
19. Lupus érythémateux	8	2	6
20. Subluxation	7	7	0
21. Arthrite gonococcique	7	2	5
22. Arthrite infectieuse	6	6	0
23. Ankylose	6	6	0
24. Arthrite aseptique	6	0	6
25. Pseudogoutte	6	1	5
26. Polyarthrite rhumatoïde	5	5	0

APPENDIX C

A TYPICAL TABULATION OF RESULTS FROM EXPERIMENT-1

APPENDIX C

A typical tabulation of results from Experiment-1.

Students

Respiratory disorders

	TF	MR	FMIN	FMAX	F1
1. Pneumonie	38	3.9	1	13	17
2. Asthme	35	5.8	1	15	4
3. Emphysème	32	4.7	1	11	1
4. T.B.	24	6	1	14	4
5. Bronchiectasie	23	6.9	2	16	
6. Pneumothorax	22	9.2	1	17	1
7. Bronchite chronique	19	4.8	1	17	2
8. Pleurésie	19	9.2	2	16	
9. Bronchopneumonie	17	7	2	14	
10. Néoplasie pulmonaire	17	7.9	1	14	2
11. Bronchite	16	3.7	1	9	4
12. Amiantose	15	7.5	3	14	
13. Oédème aigue	15	7.7	1	21	1
14. Atélectasie	14	8.9	1	16	1
15. Silicose	13	9.8	6	16	
16. Epanchement pleural	13	10	4	20	
17. Poumon du fermier	13	10.2	3	16	
18. Sarcoïdose	12	8	5	13	
19. Abcès pulmonaire	12	11	4	17	
20. Embolie pulmonaire	11	6.2	3	12	
21. Oat cell	8	9	2	15	
22. Laryngite	7	8.1	2	13	
23. Grippe-influenza	6	6.7	2	14	
24. Fibrose pulmonaire	6	7.2	3	12	
25. Néoplasie	6	7.8	2	12	

APPENDIX C continued

Respiratory disorders

	TF	MR	FMIN	FMAX	F1
26. Pharyngite	5	6.4	1	14	1
27. Insuffisance respiratoire	5	9	2	16	
28. Sidérose	5	9.2	7	11	
29. Alvéolite	5	9.6	7	11	
30. Empyème	5	9.6	4	16	
31. Bérylliose	5	11	8	15	
32. Hémothorax	5	12.6	7	18	
33. Pneumoconiose	4	4	1	8	1
34. Néoplasie épidermoïde	4	6.7	3	12	
35. Allergie	4	8.5	4	15	
36. Rhume	4	9.3	5	15	
37. Membranes hyalines	4	11	6	18	
38. Fibrose kystique	4	13.8	12	16	
39. Infarctus pulmonaire	3	5	1	9	1
40. Néoplasie pleurale	3	7.3	2	6	
41. Bronchite aigue	3	9.3	1	16	1
42. Néoplasie bronchite	3	10	8	14	
43. Adénome bronchique	3	10.3	6	14	
44. Adénocarcinome pulmonaire	3	10.7	5	16	
45. Obstruction bronchique	3	11.7	9	15	
46. Trachéite	3	11.7	9	15	
47. Sinusite	3	12.7	6	16	
48. Hypertension pulmonaire	3	13	12	14	
49. Mucoviscidose	3	13.3	9	17	
50. Emphysème centro-lobulaire	2	3.5	3	4	
51. Emphysème pan-lobulaire	2	3.5	2	5	
52. Néoplasie larynx	2	4.5	3	6	
53. Hydrothorax	2	9	5	13	
54. Polypes nasaux	2	9.5	8	11	
55. Histoplasmose	2	10	6	14	
56. Traumatisme cage thoracique	2	10	7	13	
57. Pneumonie interstitielle	2	10.5	5	16	
58. Anthracose	2	12	11	13	
59. Rhinite	2	12	10	14	
60. Atrésie pulmonaire	2	13.5	10	17	
61. Fractures de côtes	2	13.5	13	14	
62. Kyste pulmonaire	2	14.5	11	18	
63. Mésothéliome	2	14.5	12	17	

APPENDIX C continued

Respiratory disorders

		TF	MR	FMIN	FMAX	F1
64.	Syndrome restrictif	1	1			1
65.	Aérophagie	1	2			
66.	Amygdalite	1	2			
67.	Bronchiolite	1	2			
68.	Infection virale	1	3			
69.	Pneumonie lobaire	1	3			
70.	Tumeur	1	3			
71.	Néoplasie-thorax	1	4			
72.	Pneumonie alvéolaire	1	4			
73.	Bronchite asthmatiforme	1	5			
74.	Obstruction à corps étrangés	1	4			
75.	Infection mycotique	1	5			
76.	Pneumatocèle	1	5			
77.	I.V.R.S.	1	6			
78.	Pneumonie de Toeffler	1	7			
79.	Pneumothorax spontané	1	7			
80.	Rupture bronchique	1	7			
81.	Amyloïdose	1	8			
82.	Néoplasie à grandes cellules	1	8			
83.	Pneumonite	1	8			
84.	Pneumothorax sous tension	1	8			
85.	Embolie graisseuse	1	9			
86.	Pneumothorax traumatique	1	9			
87.	Alcalose respiratoire	1	10			
88.	Pachypleurite	1	10			
89.	Stridor laryngé	1	10			
90.	Tumeur bénigne-maligne	1	10			
91.	Affection des muscles respiratoires	1	11			
92.	Chylothorax	1	11			
93.	Pleurite	1	12			
94.	Volet mobile	1	12			
95.	Maladie obstructive chronique	1	13			
96.	Perforation pulmonaire	1	13			
97.	Médiastinite	1	14			
98.	Hémorragie	1	15			
99.	Syndrome de trouble respiratoire adulte	1	15			
100.	Nodule solitaire	1	19			

APPENDIX D

COMPARATIVE DATA FROM EXPERIMENT - 1: 10 TOP ITEMS

APPENDIX D-1

RESPIRATORY DISORDERS

		MR*		Virginia study	
		Students	Physicians	Rank	% of total**
1-	Emphysème	4.7	8	10	.22
2-	Pneumonie	3.9	3.7	6	.77
3-	Asthme	5.8	7.5	5	.64
4-	Bronchite chronique	4.8	5.6	11	.18
5-	Néoplasie pulmonaire	7.9	9.3	13	.07
6-	T.B.	6	9.8	14	.04
7-	Pneumothorax	9.2	10.3	15	.02
8-	Bronchite	3.7	3.5	3	2.57
9-	Trachéite		6.6	8.5	.27
10-	Laryngite		6.9	8.5	.27
9-	Bronchectasie	6.9		16	.01
10-	Pleurésie	9.2		12	.11
	Influenza			1	3.86
	Pharyngite-amygdalite			2	3.83
	Sinusite			4	.9
	Rhinite			7	.6

* Mean rank from Experiment-1

** Computed from: (x/526196)x 100

APPENDIX D-2

CARDIOVASCULAR DISORDERS

		MR		Virginia study	
		Students	Physicians	Rank	% of total
1-	Infarctus du myocarde	4.3	2.6	5	.34
2-	Angine de poitrine	4.8	3.6	4	.88
3-	Insuffisance cardiaque	5.6	4.6	3	.96
4-	H.T.A.	8.7	8.7	1	5.82
5-	Sténose aortique	6.9	5	-	-
6-	Sténose mitrale	6.5	5.6	-	-
7-	Insuffisance mitrale	7.7	6	-	-
8-	Maladie de Buerger		8.3	-	-
9-	Anévrisme aortique		9.3	-	-
10-	Artériosclérose		9.5	2	1.26
8-	Embolie	10.7		12	.07
9-	R.A.A.	8.5		11	.14
10-	C.I.V.	9.4		-	-
	Troubles du rythme			6	.33
	Phlébite-thrombophlébite			7	.29
	Insuffisance artérielle périphérique			8	.19
	Syncope			9	.18
	Varices			10	.15

APPENDIX D-3

GENITOURINARY DISORDERS

		MR		Virginia study	
		Students	Physicians	Rank	% of total
1-	Cystite	5.2	3.3	2	.92
2-	Pyélonéphrite	5.8	4.4	4	.15
3-	Urolithiase	5.8	5.4	7	.08
4-	Urétrite	8.1	5.2	5	.12
5-	Prostatite	6.5	7.8	-	-
6-	Vaginite	6.4	7.6	1	1.2
7-	Glomérulonéphrite	5.1	6	8.5	.07
8-	Salpingite	6.7	7.7	6	.11
9-	Kyste ovarien		8.4	-	-
10-	H.B.P.		6.3	8.5	.07
9-	Gonorrhée	7		3	.24
10-	Syphilis	4.9		10	.06

APPENDIX D-4

GASTROINTESTINAL DISORDERS

	MR		Virginia study	
	Students	Physicians	Rank	% of total
1- Colite ulcéreuse	7	8.1	-	-
2- Gastrite	3.3	4.3	1	.54
3- Maladie de Crohn	6.5	9.3	-	-
4- Ulcère gastrique	4.6	4.5	7	.10
5- Pancréatite	7.9	9.5	-	-
6- Appendicite	8.6	9.8	11	.04
7- Ulcère duodénal	4.8	5.3	3	.15
8- Diverticule/ite		10.8	-	-
9- Hémorroïdes		12.5	-	-
10- Oesophagite		6.2	10	.06
8- Néoplasie-estomac	6.1		13	.004
9- Néoplasie-côlon	8.2		12	.032
10- Obstruction	6.3		-	-
Hernie			4.5	.13
Cirrhose			4.5	.13
Ulcère pylorique			6	.11
Fissure anale			8	.08
Fonctionnel			2	.31
Cholécystite			9	.07

APPENDIX D-5

ENDOCRINE DISORDERS

		MR		Virginia study	
		Students	Physicians	Rank	% of total
1-	Hypothyroïdie	3.8	3.7	4	.14
2-	Hyperthyroïdie	3.6	3.5	3	.16
3-	Diabète	4.3	3.2	1	2.4
4-	Maladie de Cushing	3.7	6.8	6	.01
5-	Maladie d'Addison	4.6	6.5	5	.03
6-	Hypopituitarisme	5	7.7	-	-
7-	Acromégalie	5.2	10.3	-	-
8-	Syndrome de Sheehan		7	-	-
9-	Hypogonadisme		7.7	-	-
10-	Thyroïdite d'Hashimoto		4.6		
8-	Phéochromocytome	6.9		-	-
9-	Hyperaldostéronisme (Conn)	6.3		-	-
10-	Insulinome	6		-	-
	Obésité			2	2.03

APPENDIX D-6

MUSCULOSKELETAL DISORDERS

		MR		Virginia study	
		Students	Physicians	Rank	% of total
1-	Tendinite	3.2	6.5	7	.18
2-	Fractures	4.7	4.5	2	1.08
3-	Entorse	5.6	6.2	1	2.44
4-	Arthrite	4.1	4.7	3	.8
5-	Arthrose	4.9	7.8	-	-
6-	Bursite		6.3	6	.36
7-	Arthrite rhumatoïde		8.1	5	.39
8-	Arthrite psoriasique		8.7	-	-
9-	Hernie discale		7.9	10	.05
10-	Contusion		7.7	11	.04
6-	Luxation	6.3		-	-
7-	Paralysie	7.6		-	-
8-	Dystrophie musculaire	4.5		-	-
9-	Myasthénie grave	4.5		-	-
10-	Ostéoporose	7.5		18	.006
	Ostéoarthrite			4	.57
	Lumbago			8	.09
	Torticolis			9	.08

APPENDIX D-7

NEUROLOGICAL DISORDERS

		MR		Virginia study	
		Students	Physicians	Rank	% of total
1-	Sclérose en plaques	5.5	4.1	7	.02
2-	Méningite	2.6	4.8	11	.003
3-	A.C.V.	7	3.7	-	-
4-	Hémiplégie	4.8	3.2	-	-
5-	Thrombose cérébrale		6.7	-	-
6-	Migraine		3.1	3	.13
7-	Céphalée de tension		2.8	1	.28
8-	Tumeur cérébrale		4.7	10	.007
9-	Epilepsie		5.1	2	.23
10-	Embolie cérébrale		6.8	-	-
5-	Guillain-Barré	4.8		-	-
6-	Paralysie	3.4			
7-	Maladie de Parkinson	4.2		4	.12
8-	Paraplégie	5.2		-	-
9-	Poliomyélite	6.6		7	.02
10-	Paresthésie	6		5	.04
	Paralysie nerfs faciaux			7	.02
	Maladie de Ménière			9	.008

APPENDIX D-8

HEMATOLOGICAL DISORDERS

		MR		Virginia study	
		Students	Physicians	Rank	% of total
1-	Leucémie	3.3	2	4	.08
2-	Anémie	2.4	2.3	-	-
3-	Anémie pernicieuse (Biermer)	4.5	4.5	2	.12
4-	Anémie ferriprive	4	3.2	1	.65
5-	Maladie de Hodgkin	5.3	6.1	5	.02
6-	Polyglobulie vraie (Vaquez)	5.4	6.3	-	-
7-	Lymphome	4.6	5.6	-	-
8-	Hémophilie	5.8	6.6	-	-
9-	Mononucléose infectieuse		4.6	3	.10
10-	Leucémie myéloïde		3.3	-	-
11-	Leucémie myéloïde chronique	4.2		-	-
12-	Myélome multiple (Kahler)	6.5		-	-

APPENDIX D-9

INFECTIOUS DISORDERS

		MR		Virginia study
		Students	Physicians	% of total
1-	Pneumonie	3.5	6.4	.77
2-	Pharyngite	8.8	5.6	3.83
3-	Méningite	7.2	9.2	.003
4-	Amygdalite		5.6	3.83
5-	Sinusite		6.3	.9
6-	Cystite		12.3	.92
7-	Otite		3.9	2.36
8-	Bronchite		8.9	2.57
9-	Conjonctivite		11.6	.38
10-	Pyélonéphrite		12.5	.15
4-	Syphilis	7.6		.24
5-	Gonorrhée	8.7		.06
6-	T.B.	7.3		.21
7-	Laryngite	9.6		.27
8-	Septicémie	6.4		-
9-	Influenza	8.1		1.78
10-	Rougeole (measles)	8.4		.01

APPENDIX D-10

NEOPLASTIC DISORDERS

		MR		Virginia study
		Students	Physicians	% of total
1-	Néoplasie-estomac	5.3	5.2	.004
2-	Néoplasie-poumons	3.3	6.3	.07
3-	Oat cell	4.7	5.8	-
4-	Leucémie	5.4	7.8	.08
5-	Adénocarcinome		4.9	-
6-	Néoplasie-côlon		5.8	.03
7-	Néoplasie-seins		5.8	.06
8-	Néoplasie-oesophage		4.3	.008
9-	Néoplasie-col utérin		4.9	.017
10-	Tumeur de Wilms		9.1	-
5-	Maladie de Hodgkin	5.9		.019
6-	Néoplasie-pancréas	6.8		.01
7-	Néoplasie-rectum	8.3		.017
8-	Tumeur de Grawitz	8.4		-
9-	Lymphome	4.7		-
10-	Néoplasie-utérus	8.3		.03

APPENDIX D-11

INFLAMMATORY DISORDERS

		MR		Virginia study
		Students	Physicians	% of total
1-	Arthrite rhumatoïde	4	2.9	.39
2-	Arthrite	2.8	1.8	.8
3-	Pharyngite	7.1	3.2	3.83
4-	Conjonctivite	5.9	5.8	.38
5-	Bursite		5.4	.36
6-	Tendinite		4.2	.18
7-	Maladie de Crohn		5.9	-
8-	Goutte		5.3	.2
9-	Lupus E.		5	-
10-	Colite		6	-
5-	Otite	6.8		2.36
6-	Pancréatite	6.7		-
7-	Appendicite	5.8		.04
8-	Péricardite	6.2		-
9-	R.A.A.	5.7		.14
10-	Cholécystite	8		.07

APPENDIX D-12

DYSPNEA

		MR		Virginia study
		Students	Physicians	% of total
1-	Asthme	4.3	3.8	.64
2-	Emphysème	4.9	3.2	.22
3-	Insuffisance cardiaque	3.6	3.2	.96
4-	Pneumonie	5.7	5.8	.77
5-	Pneumothorax	5.2	7.3	.02
6-	Bronchite chronique	5.2	3.9	.18
7-	Embolie pulmonaire	4.9	6	-
8-	Néoplasie-poumons	5.2	8.9	.07
9-	Oedème aigu du poumon	4.6	5.3	.01
10-	T.B.		8	.04
10-	Bronchite	4.6		2.57

APPENDIX D-13

ABDOMINAL PAIN

		MR		Virginia study
		Students	Physicians	% of total
1-	Appendicite	3.4	2.5	.04
2-	Pancréatite	6	6.9	-
3-	Cholécystite	4.3	4.3	.07
4-	Urolithiase	7.8	9.5	.08
5-	Ulcère duodénal	6.5	8.4	.15
6-	Diverticulite		5.9	-
7-	Cholélithiase		8.5	.05
8-	Gastrite		6.1	.54
9-	Ulcère gastrique		8.4	.1
10-	Adénite mésentérique		9.6	-
6-	Péritonite	7.5		-
7-	Hépatite	8.3		.07
8-	Obstruction	5.5		-
9-	Maladie de Crohn	7.9		-
10-	Colite ulcéreuse	8.2		-

APPENDIX D-14

JOINT PAIN

		MR		Virginia study
		Students	Physicians	% of total
1-	Arthrite rhumatoïde	2.4	3.6	.39
2-	Déchirure méniscale	5.6	6.5	.06
3-	Arthrose	2.4	3.8	-
4-	Arthrite	1.6	1.5	.8
5-	Entorse	6.9	6	2.44
6-	Fractures	6.6	6.5	1.08
7-	R.A.A.	3.9	5.4	.14
8-	Arthrite gonococcique		5.7	-
9-	Goutte		6.3	.2
10-	Arthrite psoriasique		6.5	-
8-	Luxation	5.8		-
9-	Synovite	7.3		.18
10-	Bursite	5		.36

APPENDIX E

CATEGORIES AND MEMBERS USED IN THE FAMILY-RESEMBLANCE EXPERIMENT

APPENDIX E

Categories and members used in the family-resemblance experiment

STUDENTS:

High prototypicality	Medium prototypicality	Low prototypicality
1. Respiratory		
Pneumonie (7)	Membranes hyalines (6)	Hydrothorax (5.5)
Bronchite (6.5)	Sidérose (5.6)	Stridor (4.6)
2. Cardiovascular		
Infarctus du myocarde (6.9)	Tétralogie de Fallot (6)	Fibrillation auriculaire (5.8)
Athérosclérose (6.4)	Myocardite (5.8)	Angéite (4.7)
3. Genitourinary		
Uréthrite (6.8)	Pyélonéphrite (6.3)	Prolapsus utérin (5.5)
Cryptorchidie (6.4)	Orchite (6.2)	Hernie inguinale (3.2)
4. Gastrointestinal		
Colite ulcéreuse (6.9)	Mégacolon (6.3)	Cancer pancréatique (5.1)
Ulcère duodénal (6.9)	Sigmoïdite (5.9)	Hypertension portale (4.8)
5. Endocrine		
Hyperthyroïdie (6.8)	Insuffisance adrénocorticale (6.5)	Hermaphrodisme (5)
Diabète (6.8)	Adénome thyroïdien (5.5)	Mucoviscidose (2.8)
6. Musculoskeletal		
Fractures (6.8)	Bursite (6.2)	Hallux valgus (5.6)
Ostéomalacie (6.4)	Chondrosarcome (6.2)	Arthrite gonococcique (4.7)
7. Neurological		
Sclérose en plaques (6.7)	Encéphalite (6.5)	Hernie discale (5)
Poliomyélite (6.5)	Méningiome (6.3)	Myasthénie grave (4.7)
8. Hematological		
Hémophilie (7)	Purpura (6.2)	Vasculite (3.8)
Anémie (6.5)	Erythroblastose foetale (6.2)	Schistocytose (2.5)

APPENDIX E continued

High prototypicality	Medium prototypicality	Low prototypicality
9. Infectious		
Méningite (6.8)	Pied d'athlète (5.5)	Péritonite (5.3)
Septicémie (6.6)	Ostéite (5.5)	Synovite (3.7)
10. Neoplastic		
Cancer gastrique (6.8)	Rétinosarcome (6.5)	Maladie de Hodgkin (6)
Fibrosarcome (6.5)	Néphroblastome (6.5)	Lipome (3.1)
11. Inflammatory		
Arthrite (6.7)	Epidydimite (5.3)	Allergie (4.8)
Maladie de Crohn (6.2)	Vaginite (4.8)	Ascite (1.7)
12. Dyspnea		
Emphysème (6.8)	Silicose (5.5)	Sténose aortique (4.8)
Pleurésie (5.6)	Bronchiectasie (5)	Médiasténite (4.5)
13. Abdominal pain		
Appendicite (7)	Hépatite virale (4.4)	Polypes intestinaux (3.8)
Pancréatite (6.7)	Rectite (3.8)	Glomérulonéphrite (3.7)
14. Joint pain		
Arthrose (6.8)	Hydarthrose (5.8)	Ostéomyélite (4.1)
Entorse (6.6)	Chondrome (4.5)	Ostéosarcome (3.5)

APPENDIX E continued

PHYSICIANS:

	High prototypicality	Medium prototypicality	Low prototypicality
1. Respiratory			
	Pneumonie (6.9)	Embolie pulmonaire (6.4)	Histoplasmose (5.6)
	Emphysème (6.7)	Amiantose (6.3)	Sinusite (4.3)
2. Cardiovascular			
	Infarctus du myocarde (7)	Hypertension artérielle (6.3)	Fibrillation auriculaire (6.1)
	Sténose mitrale (6.3)	Tétralogie de Fallot (6.2)	Angéite (4.7)
3. Genitourinary			
	Cystite (6.5)	Cystocèle (6.2)	Prolapsus utérin (6)
	Pyélonéphrite (6.4)	Orchite (6.1)	Hydrocèle (5.5)
4. Gastrointestinal			
	Ulcère duodénal (6.8)	Néoplasie gastrique (6.3)	Hernie hiatale (5.8)
	Colite ulcéreuse (6.8)	Mégacolon (6.2)	Abcès anal (4.8)
5. Endocrine			
	Hypothyroïdie (6.7)	Phéochromocytome (6.5)	Diabète sucré (6.3)
	Adénome hypophysaire (6.7)	Testicule féminisant (6.4)	Syndrome Z-Ellison (4.2)
6. Musculoskeletal			
	Fractures (6.7)	Rachitisme (5.9)	Ostéomalacie (5.7)
	Tendinite (6)	Spondylite ankylosante (5.8)	Goutte (4.5)
7. Neurological			
	Sclérose en plaques (6.8)	Poliomyélite (6.4)	Hernie discale (4.9)
	Méningiome (6.6)	Glioblastome (6.3)	Céphalée de tension (3.5)
8. Hematological			
	Leucémie (7)	Purpura (6.3)	Anisocytose (5.6)
	Anémie (6.6)	Myélome multiple (6.1)	Toxoplasmose (2.2)

APPENDIX E continued

High prototypicality	Medium prototypicality	Low prototypicality
9. Infectious		
Septicémie (6.9)	Amygdalite (6.4)	Péritonite (6.1)
Otite (6.7)	Prostatite (6.1)	Adénite (5.6)
10. Neoplastic		
Oat cell (6.8)	Chondrosarcome (6.5)	Hépatome (6.2)
Néphrosarcome (6.7)	Maladie de Hodgkin (6.4)	Schwanome (5.2)
11. Inflammatory		
Bursite (6.5)	Myosite (6.2)	Eczéma (4.6)
Maladie de Crohn (6.3)	Lupus érythémateux (5.3)	Allergie (4.4)
12. Dyspnea		
Asthme (7)	Pleurésie (5)	Sarcoïdose (4.2)
Membranes hyalines (6.8)	Bronchiectasie (4.3)	Sténose aortique (4.2)
13. Abdominal pain		
Appendicite (6.9)	Endométriose (5.9)	Diverticule de Meckel (5.2)
Pancréatite (6.8)	Hépatite (5.3)	Hernie inguinale (4.5)
14. Joint pain		
Arthrite rhumatoïde (6.6)	Luxation (6.4)	Dermatomyosite (4.2)
Arthrose (6.4)	Hydarthrose (5.7)	Sclérodermie (4.2)

APPENDIX F

A TYPICAL TABULATION OF RESULTS FROM EXPERIMENT - 3

APPENDIX F

A typical tabulation of results from Experiment-3

Students

Pneumonie

		F	F1	MR
1.	Toux	10	1	4.7
2.	Fièvre	9	1	6.1
3.	Expectoration	8		6.6
4.	Pneumocoque	7	1	6.3
5.	Dyspnée	5	1	4.6
6.	Streptocoque	5		5.2
7.	Hémoptysie	5		6.6
8.	Consolidation pulmonaire	5		6.6
9.	Mycoplasme	5		8.8
10.	Infection pulmonaire	4	3	1.3
11.	Bactérie	4		3.3
12.	Lobaire	4	1	5
13.	Radiographie pulmonaire	4		9
14.	Infection	3	1	2.3
15.	Matité	3	1	5.7
16.	Klebsiella	3		6
17.	Points de côté	3		6
18.	Antibiothérapie	3		8.3
19.	Maladie pulmonaire	2	2	1
20.	Poumons	2	2	1
21.	Bronchogramme aéré	2		3.5
22.	Alvéolaire	2		4.5
23.	Râles	2		4.5
24.	Origine alvéolaire	2		4.5
25.	Interstitielle	2		4.5
26.	Mycobactérie	2	1	4.5
27.	Expectorations purulentes	2		5.5
28.	Origine bronchique	2		6
29.	Epanchements	2		8
30.	Frissons	2		8
31.	Culture des expectorations	2		9
32.	Murmure vésiculaire diminué	2		9.5
33.	TB	2		9.5
34.	Opacité à radiographie	1		2
35.	Douleur à respiration	1		2
36.	Atteinte état général	1		2
37.	Exsudat	1		3
38.	Couleur des expectorations	1		3

APPENDIX F continued

Pneumonie

	F	F1	MR
39. Réaction pleurale	1		4
40. Résolution en quelques jours	1		5
41. H. Influenza	1		6
42. Abcès	1		6
43. Râles crépitants	1		7
44. Bactériémie	1		7
45. Staphylocoque	1		7
46. Atélectasie	1		8
47. Bronchopneumonie	1		8
48. Viral	1		8
49. Origine parenchymateuse	1		8
50. Pectoriloquie aphone	1		9
51. Culture des expectorations	1		9
52. Trois grosses images à radiographie	1		9
53. Tympanisme	1		10
54. Douleur pleurale	1		10
55. Amplitude diminuée	1		10
56. Pseudomonas	1		10
57. Brossage bronchique	1		10
58. Pénicilline	1		11
59. Bronchoscopie	1		11
60. Bronchite	1		13

APPENDIX G

CATEGORIES AND INSTANCES USED IN THE RESPONSE-TIME EXPERIMENT

APPENDIX G

Categories and members used in the response-time experiment

STUDENTS:

Category	Central member	Peripheral member
1. Respiratory	Pneumonie (7)* Bronchite (6.5)	Hydrothorax (5.5) Stridor (4.6)
2. Cardiovascular	Infarctus du myocarde (6.9) Sténose mitrale (6.5)	Fibrillation auric. (5.8) Angéite (4.7)
3. Genitourinary	Uréthrite (6.8) Vaginite (6.8)	Prolapsus utérin (5.5) Hernie inguinale (3.2)
4. Gastro-intestinal	Colite ulcéreuse (6.9) Ulcère duodénal (6.9)	Hypertension portale (4.8) Cancer pancréatique (5.1)
5. Endocrine	Maladie de Cushing (6.9) Diabète (6.8)	Hermaphrodisme (5.0) Mucoviscidose (2.8)
6. Musculoskeletal	Fractures (6.8) Ostéomalacie (6.4)	Halux valgus (5.6) Arthrite gonococcique (4.7)
7. Neurological	Sclérose en plaque (6.7) Encéphalite (6.5)	Myasthénie grave (4.7) Hernie discale (5)
8. Hematological	Hémophilie (7) Leucémie (6.7)	Schizocytose (2.5) Vasculite (3.8)
9. Infectious	Meningite (6.8) Pneumonie (6.7)	Synovite (3.7) Péritonite (5.3)
10. Neoplastic	Cancer gastrique (6.8) Néphroblastome (6.5)	Leucémie (6.0) Lipome (3.1)
11. Inflammatory	Arthrite (6.7) Laryngite (6.4)	Ascite (1.7) Allergie (4.8)
12. Dyspnea	Emphysème (6.8) Membranes hyalines (6.0)	Sténose aortique (4.8) Médiastinite (4.5)
13. Abdominal pain	Appendicite (7) Pancréatite (6.7)	Rectite (3.8) Glomérulonéphrite (3.7)
14. Joint pain	Arthrose (6.8) Entorse (6.6)	Osteosarcome (3.5) Ostéomyélite (4.1)

* Mean rank from Experiment - 2 in parenthesis.

APPENDIX G continued

PHYSICIANS:

	Category	Central member	Peripheral member
1.	Respiratory	Emphysème (6.7) Pneumonie (6.9)	Histoplasmose (5.6) Sinusite (4.3)
2.	Cardiovascular	Infarctus du myocarde (6.9) Hypertension artérielle (6.3)	Fibrillation auric. (5.8) Angéite (4.7)
3.	Genitourinary	Cystite (6.5) Vaginite (6.2)	Prolapsus utérin (6) Hydrocèle (5.5)
4.	Gastro-intestinal	Colite ulcéreuse (6.8) Ulcère duodénal (6.8)	Hernie hiatale (5.8) Abcès anal (4.8)
5.	Endocrine	Maladie de Cushing (6.7) Diabète (6.3)	Testicule féminisant (6.4) Syndrome Zollinger-Ellison (4.2)
6.	Musculoskeletal	Fractures (6.7) Entorse (6.4)	Ostéomalacie (5.7) Rachitisme (5.9)
7.	Neurological	Sclérose en plaques (6.8) Poliomyélite (6.5)	Hernie discale (4.9) Myasthénie grave (4.7)
8.	Hematological	Hémophilie (6.9) Leucémie (7)	Anisocytose (5.6) Toxoplasmose (2.2)
9.	Infectious	Otite (6.7) Amygdalite (6.4)	Adénite (5.6) Péritonite (6.1)
10.	Neoplastic	Cancer pancréatique (6.9) Maladie de Hodgkin (6.4)	Hépatome (6.2) Schwanome (5.2)
11.	Inflammatory	Bursite (6.1) Tendinite (6.3)	Eczema (4.6) Allergie (4.4)
12.	Dyspnea	Asthme (7) Membranes hyalines (6.8)	Sténose aortique (4.2) Sarcoïdose (4.2)
13.	Abdominal pain	Appendicite (6.9) Pancréatite (6.9)	Hépatite (5.3) Hernie inguinale (4.5)
14.	Joint pain	Arthrite rhumatoïde (6.6) Arthrose (6.4)	Dermatomyosite (4.2) Sclérodermie (4.2)

APPENDIX H

INSTANCES AND CATEGORIES USED AS FALSE STATEMENTS IN THE RESPONSE-TIME EXPERIMENT

APPENDIX H

Members and categories used as false statements in the response-time experiment

MEMBER	CATEGORY
Oésophagite	Douleurs articulaires
Sclérodermie	Néoplasie
Pneumonie alvéolaire	Gastro-intestinale
Vasculite	Neurologique
Migraine	Gastro-intestinale
Dermatomyosite	Hématologique
Névrose	Infection
Cervicite	Gastro-intestinale
Hyperparathyroïdie	Neurologique
Fistule utéro-vaginale	Respiratoire
Pneumoconiose	Génito-urinaire
Endométriose	Cardio-vasculaire
Tendinite d'insertion	Endocrinien
Hémiparésie	Néoplasie
Polynévrite	Génito-urinaire
Moniliase	Cardio-vasculaire
Insulimome	Douleurs articulaires
Herpes zoster	Néoplasie
Mononucléose infectieuse	Néoplasie
Diabète insipide	Hématologique
Eclampsie	Musculo-squelettique
Aplasie médullaire	Génito-urinaire
Intussusception	Endocrinien
Péricardite	Musculo-squelettique
Glissement épiphysaire	Respiratoire
Astrocytome	Infection
Angéite	Néoplasie
Pneumonite	Génito-urinaire

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