Problem Solving: Stages, Strategies, and Stumbling Blocks

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Problem solving refers to a class of activities that are directed toward attainment of a goal. The stages of problem solving involve problem definition, selection of a strategy, implementation of the strategy, and evaluation of the solution. Solutions can be based on strategies involving insight, trial-and-error, hypothesis testing, algorithms, or heuristics. In rehabilitative audiology most clinical problems are likely to be approached using heuristics: rules of thumb that are likely, but not guaranteed, to yield an acceptable solution. General heuristics and biases that characterize human judgment and decision-making under uncertainty are viewed as stumbling blocks to effective problem solving.

Problem solving has been conceptualized in terms of such processes as association, perceptual organization and reorganization, judgment, reasoning, and, more recently, information processing. Given this diversity of approaches, it is not surprising that there is no single, accepted definition of the term *problem*; nevertheless, a common theme (Kaufmann, 1980) is goal attainment. A problem is said to exist when an individual does not know how to attain a particular goal or is in some way prevented from achieving it. That is, there is uncertainty about what action, or what sequence of responses, will lead from the current state of affairs to another, desired state. Without motivation for change, there is no problem.

One important class of problems is the acquisition of knowledge or information. As noted by Johnson (1972), a problem is frequently posed by a question whose answer is not known. This observation is consistent with the nearly synonymous usage of the terms *research problem* and *research question* in scientific investigations. Although general methodologies have evolved for

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solving large classes of problems (e.g., the scientific method), their implementation and adaptation to a specific problem is not always obvious and may constitute a problem in its own right.

The purpose of this paper is to provide a brief and selective overview of problem solving as it has been approached theoretically and empirically by psychologists. Most of the principles and generalizations that emerge are characteristic of problem solving in general, but their potential relevance to problem solving in rehabilitative audiology will be illustrated.

STAGES IN PROBLEM SOLVING

Problem Definition

It seems axiomatic that one cannot solve a problem unless one knows what the problem is. Indeed, proper definition of a problem may be the key element in its solution. Precisely this position has been taken by Turkat (1985) in his discussion of case formulation in clinical psychology. Turkat's premise is that effective intervention depends on "a good formulation of the phenomenon targeted for change" (p. 2). A related point is that precise definition of the problem also leads to criteria for evaluating a solution (to be further discussed in a later section).

Although problem definition is generally acknowledged to be important, its placement in the temporal sequence of problem solving may depend on the nature of the problem. For example, Golightly (1981) developed a model for medical problem solving that does not begin with problem definition. Golightly was concerned with problem solving as a managerial function in health care settings and she contended that complex problems are often defined at first by a set of symptoms. That is, one knows that a problem exists, but is not certain of its nature or extent. She recommended a systematic data-gathering phase as a prelude to problem definition. Wolpe and Turkat (1985) also stressed the need for intensive data collection and hypothesis testing in arriving at an appropriate formulation of the problem presented by a client. Thus accurate problem definition — at some point — has been viewed as a requisite to effective problem solving both at the institutional and individual levels.

In rehabilitative audiology many problems are made more difficult by inadequate or inconsistent definition of terms. Some progress has been made in distinguishing between *hearing impairment* and *hearing handicap* (Giolas, 1982), but other terms are not so clearly delineated. For example, in reviewing the literature on self-report approaches to assessing benefit from amplification, Demorest (1984) found that hearing aid *benefit, use,* and *satisfaction* were not consistently distinguished, either between or within studies. Similarly, Caccamise and Newell (1984) recently reviewed inconsistent use of terminology in deaf education (e.g., *total communication* vs. *simultaneous communication*). The ability to resolve important philosophical, theoretical, and educational issues can be severely hampered by lack of consensus on definitions.

Selection of a Strategy

Truly novel problems require a novel approach and the individual who finds a solution is often characterized as creative. Except for specially contrived problems or puzzles, however, most real-world problems, including those that arise in clinical settings, share features or characteristics with problems that have been encountered and solved before. Generalizing from experience, we tend to adopt strategies that have been successful in the past. In the experimental literature this is referred to as a set.

Sets can have either a facilitative or a detrimental effect on problem solving (see the section on stumbling blocks below). Problem solving efficiency is clearly enhanced if one does not continually reinvent the wheel. On the other hand, routine and unquestioning application of any approach can result in solutions that are less than optimal or that are inefficiently obtained. This effect is dramatically illustrated in the famous Luchins water jar problems (Luchins, 1942). Luchins presented a series of problems of the same form as shown in Appendix A. They involved drawing a certain amount of water using a large jar and two smaller jars. Most of the problems can be solved (though not necessarily efficiently) in a series of steps by successive subtractions of water from the large jar. The set established by practice on several problems of this type can lead to (a) routine application of the strategy even for a problem that can be solved more directly with a single addition or subtraction (Appendix A, Problems 7, 8, 10, 11) and (b) failure on an otherwise simple problem that *cannot* be solved using the strategy (Appendix A, Problem 9). The point is that one cannot suspend critical evaluation of existing problem-solving strategies. Rigid adherence to a strategy and failure to consider alternative strategies or methods are clearly deterrents to innovation and change.

Implementation of a Strategy

In the experimental and theoretical literature on problem solving, it is not customary to focus on implementation of a strategy as a separate stage. However, in applied settings, one may know what constitutes an appropriate strategy, but lack the resources to implement it. An example is the problem of evaluating the effectiveness of sensory devices, such as tactile aids or cochlear implants, in children. In order to conclude that a device has affected the development of auditory, cognitive, or other abilities, it is necessary to compare the performance of children who have used the device to the performance of a reference group who have not. Such comparisons are fraught with methodological difficulties at best, but one acceptable strategy is to utilize developmental norms obtained from a large, representative, sample of hearing-impaired children (Demorest, 1985; Tyler et al., 1986). The difficulty of implementing this strategy arises from the unavailability of such a database and the obvious cost of establishing one. Lack of resources thus becomes a significant impediment to solution of the problem.

Evaluation of the Solution

A problem is said to be well-defined when it is clear whether or not a solution has been obtained (Miller, Galanter, & Pribram, 1960). For complex problems, the existence and identity of an adequate solution may be controversial. For example, there may be disagreement about the criteria for an adequate solution and/or there may be difficulty in obtaining evidence regarding the criteria. If there is no way to test the adequacy of a proposed solution, the problem remains ill-defined. As a result, we may persist in our use of less-than-optimal strategies.

A possible example of this state of affairs in audiology is the problem of hearing aid selection. If the goal of hearing aid selection is to maximize the benefit derived from amplification, then the problem cannot be considered well-defined until we have defined *benefit*. That is, we must identify appropriate criteria for assessing an individual's performance with a hearing aid. Given appropriate outcome criteria, we can proceed to evaluate various strategies for hearing aid selection (Hawkins, 1985; Walden, 1982). In the interim, traditional strategies such as the comparative hearing aid evaluation are employed, although there is evidence that the assumptions underlying that procedure are not valid (Walden, Schwartz, Williams, Holum-Hardegen, & Crowley, 1983).

STRATEGIES FOR PROBLEM SOLVING

Insight, Trial-and-Error, and Hypothesis Testing

Early studies of problem solving in animals by Kohler, Yerkes, and Thorndike (cited in Johnson, 1972, and Vinacke, 1974) contrasted insight with trial-and-error, as the basis of problem solving. Kohler and Yerkes, studying primates, found evidence of insight, a sudden recognition of the solution to a problem. The elements of the solution were available in the situation and insight was usually preceded by exploration or information-gathering activity which did not in itself provide the solution, but which appeared to be a prerequisite for it. Thorndike, on the other hand, found that a cat placed in a puzzle box would engage in a series of essentially random responses that very gradually led to a solution, the elements of which were hidden from view. Insightful solutions were thought to reflect perceptual organization and reorganization, whereas trial-and-error was thought to involve the gradual establishment of associations between stimuli and responses.

We still do not understand the nature of insight, but if we can generalize from the research literature, the chances of solving a problem by insight are likely to be improved by active exploration as compared to passive contemplation. Trial-and-error behavior is likewise not guaranteed to yield success. Yet, in a situation where we have no hunches whatever, the only alternative may be to try something, anything, and to see if it works.

Most trial-and-error problem solving is pre-theoretical and non-rational in nature. A different term, hypothesis testing, is used when trial-and-error behavior follows a clearly formulated and reasoned *if-then* approach to the problem. For clinicians, hypothesis testing represents a major problem-solving strategy, especially as it relates to diagnosis (Elstein, Shulman, & Sprafka, 1978). The term also highlights the similarity between clinical problem solving and the methodology of scientific research.

Algorithms and Heuristics

When a problem is well-defined, it can sometimes be shown that there is a systematic, step-by-step procedure that is guaranteed to yield a solution. Such a strategy is called an *algorithm* (Miller et al., 1960), and the term is not applied unless there is consensus that the procedure solves the problem. Some familiar examples of algorithms include rules for dividing by a fraction, for finding the square root of a number, or for figuring income tax. As these examples illustrate, it is possible to execute an algorithm without any comprehension of why it works.

When there exists more than one algorithm for solving a particular problem, the most efficient algorithm is generally considered the best. The advent of microcomputers in audiology has had a major impact on data collection, data processing, program management, and other tasks amenable to automatization. These are all examples of the advantage of having efficient algorithms.

A problem-solving strategy is not considered an algorithm unless it is clear that it solves the problem. This means that the problem must be well-defined and that the criteria for an acceptable solution must be fulfilled. Unfortunately, for the majority of clinical problems these conditions are not met. In such situations, problem-solving strategies are referred to as heuristics. A *heuristic* is a rule-of-thumb that represents our best guess about how to solve the problem. The term refers to the "art of discovery" (Miller et al., 1960, p. 160) and comes from the Greek *heuriskein,* to discover. *Webster's new collegiate dictionary* (1975) describes a heuristic procedure as "providing aid or direction in the solution of a problem but otherwise unjustified or incapable of justification; of or relating to exploratory problem-solving techniques . . ." (p. 538).

Examples of heuristics in rehabilitative audiology abound. The comparative hearing aid evaluation is a notable example whose heuristic status derives from the ill-defined nature of the problem. The many computer-based schemes for hearing aid selection and evaluation (Jackson, 1986) illustrate formalized strategies for optimizing performance with a hearing aid. The fact that different hearing-aid selection procedures do not produce the same results is one indication that they are heuristics rather than algorithms. Educational placement of a deaf child is another problem that is approached heuristically. Recently, an attempt has been made to objectify and standardize this procedure using a Spoken Language Predictor index (Geers & Moog, in press). As this brief list illustrates, some heuristics are formal, clearly articulated, objective, and replicable. The vast majority of heuristics, however, are implicit, not overtly articulated, and simply represent common practice.

STUMBLING BLOCKS

Reference has already been made to several factors that can impede problem solving. This section examines some stumbling blocks that reflect general operating characteristics of human reasoning, judgment, and choice. Some have been explored within the context of research on problem solving per se, but many have grown out of studies of human cognition that have even broader implications concerning beliefs, attitudes, and our propensity for errors in reasoning. Although there may be some individual differences in susceptibility to these phenomena, they do not reflect formal training in logic, psychology, or statistics! (The reader who wishes to experience some of these stumbling blocks first-hand is invited to take the quiz in Appendix B before proceeding further.)

Perseveration

To persevere toward a goal is valued positively when it reflects commitment, dedication, and other attributes that connote refusal to accept defeat. The factor that can make perseverance a detriment to problem solving is inflexibility or resistance to an alternative view.

Mental Set. There is clearly a positive value in adopting problem-solving strategies that have been successful in the past, hence there is a strong inclination to persist in using them. The difficulty lies in detecting those problems for which the strategy is either not appropriate or not optimal. The Luchins water-jar problems presented above illustrate this.

Fixation. Whereas set refers to perseverance in the use of a particular strategy, fixation refers to a persistent manner of viewing the elements of the problem. The classic examples of fixation in the experimental literature concern functional fixedness, the tendency to perceive the function of an object in a fixed way. In Duncker's candle problem (Johnson, 1972) the subject must support a candle on a door at eye level; the available materials include candles, matches, tacks, and some small boxes. The correct solution is to use the tacks to mount the box and to stand the candle in the box. The solution is much more difficult if the tacks or candles are presented to the subject in the box. Seeing the box as a container inhibits seeing it as a platform.

Belief perseverance. Once an individual becomes committed to a particular belief, there is a strong tendency to persist in that belief. Lord, Ross, and Lepper (cited in Myers, 1986) identified two groups of students who were on different sides of a controversial issue. They then presented the students with fictitious results of two studies that came to different conclusions about the issue. Each group accepted the results which confirmed its beliefs and disputed those that were contradictory. Although identical information was given to the two groups, it increased the disagreement between them. But it is not just strong beliefs on controversial topics that are impervious to change. In another study cited by Myers (1986), Lepper presented materials that induced opposite beliefs in two groups of subjects. When the basis for those beliefs was later discredited, the attempt to reverse the subjects' conclusions had little impact. They tended to cling to their earlier explanations about why their beliefs made sense. Similar behavior has been observed in clinicians. It has been found that clinicians quickly assimilate the information they receive and formulate a tentative hypothesis. Additional information seems to have progressively less and less impact on their beliefs (Elstein et al., 1978; Wiggins, 1973, Ch. 4).

Confirmation Bias

Closely related to perseveration is confirmation bias: a tendency to seek evidence that can confirm a hypothesis rather than refute it. This can be illustrated by a task introduced by Wason (1968) and reproduced as Item 1 in Appendix B. The subject must verify whether a particular rule is correct by examining instances that may confirm or disconfirm the rule. Nearly all subjects selected the instance that can either confirm or disconfirm the rule (Card A). However, a majority of subjects made errors (a) by selecting an instance that could confirm the rule but that could not disconfirm it (Card 2) and (b) by failing to select a card that could disconfirm the rule but that could not confirm it (Card 3). Even with explanation, many individuals did not immediately grasp that the only relevant choices are instances that can potentially disconfirm the rule. We look for examples that are consistent with what we believe, and we often do not notice the (negative) relevance of other examples. We do not seek out disconfirming evidence.

Overconfidence

Overconfidence is a general tendency for individuals to underestimate the likelihood that their beliefs are in error. A simple illustration of this is provided by Item 2 in Appendix B (Kahneman & Tversky, cited in Myers, 1986). A group of individuals was asked to respond to this item. If the judges were neither over- nor under-confident, the range of values they provided should have included the correct value (189) 98% of the time. In fact, the judges failed to include the correct answer one third of the time.

In a classic study of overconfidence in clinical judgments, Oskamp (1965/1982) examined the relationships among amount of information available, judgmental accuracy, and confidence. Relevant information about an actual case study was presented to 32 judges in four stages. The judges had various degrees of training and experience in psychology, but this factor was found to be irrelevant. At each stage the judges responded to 25 multiple-choice questions whose answers could be inferred from the complete case study. Table 1 shows the results. Although judgmental accuracy differed slightly at the four stages, it was not significantly better than chance (20%) and it did not systematically improve with increasing amounts of relevant information. This finding is consistent with those cited above concerning persistence of beliefs. What is even more striking is the strong and consistent increase in confidence across the four stages and the decrease in the number of answers that were changed.

Table 1
Performance of 32 Judges on a 25-item Case Study Test

Measure	Stage 1	2	3	4	*F*	*p*
Accuracy (%)	26.0	23.0	28.4	27.8	5.02	.01
Confidence (%)	33.2	39.2	46.0	52.8	36.06	.001
Number of Changes	—	13.2	11.4	8.1	21.56	.001

Note. From "Overconfidence in case-study judgments" by S. Oskamp, 1965, *The Journal of Consulting Psychology, 29,* p. 264. Copyright 1965 by the American Psychological Association. Reprinted by permission.

The implication for clinical problem solving is that confidence in the correctness of one's judgments and beliefs is not necessarily related to accuracy. Initial impressions formed early in the attempt to solve a problem may be a significant deterrent to its eventual solution. Fortunately, there is some limited but encouraging evidence that clinicians can be trained to use special heuristics that guide the formulation, evaluation, and revision of hypotheses (Elstein et al., 1978).

Framing

Item 3 in Appendix B illustrates that the way a problem is presented has an impact on how it is solved. Subjects were asked to make a judgment about how to prepare for a disaster that is expected to kill 600 people. The options were presented as (a) certain salvation for 200 individuals or (b) a 1/3 probability that 600 would be saved and a 2/3 probability that no one would be saved. Kahneman and Tversky (cited in Myers, 1986) found that their subjects chose the first option about 3:1. Remarkably, the preferences became 3:1 for the second option when the same alternatives were recast in terms of death. Although it is logically equivalent to state that 200 will be saved and to state that 400 will die, it is not psychologically equivalent.

This effect has been called framing: the way a problem is stated has an effect on the strategy adopted. It may be considered a stumbling block to problem solving because it imposes another constraint on the strategies we are willing to consider. Whether one emphasizes the potential benefits or the risks associated with a particular strategy may have a direct influence on willingness to employ that strategy. This conclusion has obvious implications regarding controversial interventions such as cochlear implants in children.

The Representativeness Heuristic

Problem solving frequently requires that we make judgments under conditions of uncertainty. Decisions must often be based on partial information and predictions must often be made according to subjective assessment of probabilities. In the past 20 years substantial progress has been made in understanding the heuristics that individuals naturally use in exercising judgment (Kahneman, Slovic, & Tversky, 1982). This section and the next examine two such heuristics: representativeness and availability. These strategies often lead to correct judgments but they can also produce systematic biases when they are inappropriately applied. It is only in the latter instance that they are stumbling blocks to problem solving.

Representativeness is a heuristic that is employed when we judge probabilities on the basis of similarity to a standard or to a presumed underlying process. It is easier to illustrate than to define. In the following examples, judgments are erroneously based on representativeness rather than on the relevant factors determining the probabilities.

Base Rates and Prior Probabilities. The following example appears as Item 4a in Appendix B. When Tversky and Kahneman (1980) asked subjects to judge whether the individual described was a lawyer or an engineer, the typical respondent indicated a very high level of certainty that he was a lawyer. Despite the fact that, a priori, the randomly selected individual is more likely (7:3) to be an engineer, the description represents the stereotype of a lawyer. The evidence swayed judgment so strongly that the prior probabilities were essentially ignored. In fact, manipulating the prior probabilities (e.g., changing to 3:7) had a negligible effect on the outcome. What was even more surprising was that subjects used the prior probabilities (70% or 30%) only when they were given *no* other information. Presenting irrelevant information (Item 4b in Appendix B) produced subjective probabilities of 50% (Kahneman & Tversky, 1973/1982)!

Sample Size. When a sample is drawn from some population, the a priori likelihood of various outcomes is determined in part by the size of the sample. When judges are asked to estimate these likelihoods, however, they tend to assume that similar outcomes are equally likely, regardless of sample size. This is illustrated in Appendix B, Item 5. Kahneman and Tversky (1972/1982) found that a majority of subjects believed a particular result (more than 60% boys) to be equally likely in the two samples. Judges also inferred that a sample which more closely represents its population is more likely than one which is less representative, even when the samples are of different size. For example, the probability that 100% of the babies are boys in the small hospital is actually *greater* than the probability that 80% of the babies are boys in the large sample. However, because the former outcome is more extreme (less representative) it was judged less likely. Intuitive reasoning (even that of experienced statisticians) does not conform to the facts of sampling theory. We erroneously judge the likelihood of an outcome by how well it represents the parent population.

Misconceptions of Chance. Truly random processes can produce outcomes that have the appearance of non-randomness. However we do not take these exceptions into account; we expect chance events to always be representative of the underlying random process that generates them. Indeed, one need only listen to sportscasters trying to explain two- and three-game losing streaks to appreciate our strong urge to account for outcomes that appear to be systematic rather than random.

Bar-Hillel (1982) has explored some factors that contribute to perceptions of randomness. Item 6 from Appendix B is adapted from his experiment. When subjects were asked whether Outcome 1 or Outcome 2 was more likely, 95% selected Outcome 1. When comparing Outcome 1 with Outcome 3, 78% chose Outcome 1. In fact, Bayesian statistics can be used to show that Outcome 2 has the highest likelihood, and that Outcomes 1 and 3 are equally likely. Outcome 2 appeared to be unlikely because the observations are identical; the parent distribution of heights was variable, so subjects expected the sample to show variability. Outcome 3 was judged less likely because all of the observations were below average, whereas it was expected that some observations would be above average and some would be below. The results were considered evidence of a representativeness heuristic because cues seemed to be integrated into an overall impression of how closely the sample matched the population from which it was drawn.

Another example is provided by Item 7. In a family of six children the birth order G B G B B G appears fairly random. An outcome with three boys and three girls is representative of the expected ratio of boys to girls and the sequence has no long runs of either gender. In comparison, Kahneman and Tversky (1972/1982) found that the sequence B B B G G G was judged less likely. When the number of boys was increased to five, 82% believed that the sequence B G B B B B was less likely than the seqence G B G B B G. In fact, *all* specific birth orders of six children are equally likely ($p = .5^6$). The number of boys and girls is irrelevant in this problem, as is the number and length of runs, but these are important aspects of the sample's representativeness.

The Availability Heuristic

It is easy to recall instances of events that occur frequently and it is easy to give examples of classes that have many members. According to Tversky and Kahneman (1973/1982), "a person is said to employ the availability heuristic whenever he estimates frequency or probability by the ease with which instances or associations could be brought to mind" (p. 164). The drawback of this strategy is that availability in memory is also influenced by factors that are unrelated to frequency and probability of occurrence. Some examples follow.

Retrievability. When subjects are asked to respond to questions like Item 8 in Appendix B, they find it easier to recall words beginning with a given letter than to recall words by other letter positions. As a result of this memory search strategy they erroneously conclude that words beginning with a given letter are more numerous than words containing that letter in another position (Tversky & Kahneman, 1973/1982). In fact both *r* and *k* are more frequent in the third position in English. Other factors that can affect memory recall are context and salience. Contextual cues can facilitate memory retrieval and highly salient instances are more easily recalled than less salient ones. Incidental cues based on the current situation or on recent experience can therefore bias our estimates of probability.

Imaginability. In a series of studies, Tversky and Kahneman (1973/1982) mustered evidence for the contention that in certain types of frequency estimation problems, subjects construct exemplars and, based on the ease of doing so, extrapolate to estimate the total number. Item 9 in Appendix B provides an illustration. In attempting to estimate the number of combinations of 7 or 3 people from a group of 10, many individuals attempted to imagine possible subsets. The strategy seems less difficult in the second case because one can readily imagine three non-overlapping groups of 3 out of 10, but only one group of 7 out of 10. Although the correct answer is the same for both questions (120), subjects' mean estimates were about 30 and 50 respectively. The relative ease of constructing exemplars was thus related to the estimate of frequency.

EPILOGUE

If there has been one recurrent theme in this review it is the need for openness and flexibility in problem solving. The tendency to establish sets, to persist in our initial beliefs, and to be overly confident in our judgment all work against innovation and instead foster conservatism and tradition. Although traditional approaches may in fact be the best ones, this assumption should not go unchallenged. In addition, it is important to be aware of the biases and misconceptions that are characteristic of human judgment and reasoning. Because many of the problems we address are not well-defined, it is essential that we continually subject our heuristics to critical evaluation. At the same time, we should be striving for more adequate problem definition so that ultimately our solutions can be validated.

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APPENDIX A

The following are Luchins' (1942) water-jar problems. Consider two jars, A and B, holding 29 and 3 quarts respectively. Use these jars to obtain 20 quarts of water. Now try the remaining problems using three jars, A, B, and C. (You may take up to 2½ min to find a solution to each problem.)

	Jar Capacity			
Problem	**A**	**B**	**C**	**Required amount**
2	21	127	3	100
3	14	163	25	99
4	18	43	10	5
5	9	42	6	21
6	20	59	4	31
7	23	49	3	20
8	15	39	3	18
9	28	76	3	25
10	18	48	4	22
11	14	36	8	6

APPENDIX B

The problems below have been adapted from examples given in Kahneman, Slovic, and Tversky (1982), Myers (1986), and Wason (1968). Findings based on these and similar problems illustrate the widespread application of certain heuristics in human judgment and problem solving.

1. Each card below has a letter on one side and a number on the other. You are asked to test the following rule about the numbers and letters: If there is a vowel on one side of the card, then there is an even number on the other side of the card. Indicate which cards you should turn over to discover whether the rule is true or false.

A	B	2	3
______	______	______	______

2. I feel 98% confident that the number of nuclear power plants operating in the world in 1980 was more than ______ and less than ______.

3. Imagine that the United States is preparing for the outbreak of an unusual Asian disease which is expected to kill 600 people. Two alternative programs to combat the disease have been proposed. If program A is adopted, 200 people will be saved. If program B is adopted, there is a 1/3

probability that 600 will be saved, and a 2/3 probability that nobody will be saved. Which program would you prefer? Answer: ______

4. A panel of psychologists interviewed a sample of 30 lawyers and 70 engineers and summarized their impressions in thumbnail descriptions of those individuals. The following descriptions have been drawn at random from the sample of 30 lawyers and 70 engineers:

a. John is a 39-year old man. He is married and has two children. He is active in local politics. The hobby that he most enjoys is rare book collection. He is competitive, argumentative, and articulate. What is the probability that this is a lawyer rather than an engineer? Answer: ______

b. Dick is a 30-year old man. He is married with no children. A man of high ability and motivation, he promises to be quite successful in his field. He is well-liked by his colleagues. What is the probability that this is a lawyer rather than an engineer? Answer: ______

5. A certain town is served by two hospitals. In the larger hospital about 45 babies are born each day, and in the smaller hospital about 15 babies are born each day. As you know, about 50% of all babies are boys. However, the exact percentage varies from day to day. Sometimes it may be higher than 50%, sometimes lower. For a period of one year, each hospital recorded the days on which more than 60% of the babies were boys. Which hospital do you think recorded more such days? a) the larger hospital; b) the smaller hospital; c) about the same (that is, within 5% of each other).

6. The average height of American college men is 175 cm. Three files were randomly drawn from a college registrar's office, belonging to John, Mike, and Bob. Which outcome is most likely with respect to the heights of these three men? Answer: ______ Which outcome is least likely? Answer: ______

Outcome 1	Outcome 2	Outcome 3
John, 178 cm	John, 177 cm	John, 172 cm
Mike, 170 cm	Mike, 177 cm	Mike, 170 cm
Bob, 176 cm	Bob, 177 cm	Bob, 174 cm

7. All families of six children in a city were surveyed. In 72 families the *exact order* of births of boys and girls was G B G B B G. What is your estimate of the number of families surveyed in which the *exact order* of births was B B B G G G? Answer: ______ What about B G B B B B? Answer: ______

8. Suppose one samples a word (of three letters or more) at random from an English text. Is it more likely that the word starts with *r* or that *r* is the third letter? Answer: ______ Is it more likely that the word starts with *k* or that *k* is the third letter? Answer: ______

9. Consider a group of 10 people who have to form a committee. How many different committees of 7 members can they form? Answer: ______ How many different committees of 3 members can they form? Answer: ______