DAVE: AN EXPERT SYSTEM FOR THE ANALYSIS OF
THE WECHSLER ADULT INTELLIGENCE SCALES AND RELATED INFORMATION

by

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Preface

Some of the terms used in this report are common to the psychology field, but not to computer science. Also, there are some idiosyncratic terms. The glossary should clarify those terms.

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Introduction

One of the most challenging activities of the human mind is clinical psychological diagnosis. That activity involves one mind attempting to discover the strong and weak properties of another mind. The responsibility is a very heavy one, for the findings bear directly upon how a human being will be treated. Clinical psychologists commonly face heavy demands upon their time and energy, and they realize that they cannot sacrifice accuracy for speed. Therefore, any tool which would relieve some of their burden would very likely be appreciated.

Testing has been a part of the clinical psychologist's duties for a relatively long time, and the psychological testing field has matured sufficiently to make certain tests a routine part of the clinician's test battery. One such test is the Wechsler Adult Intelligence Scales (WAIS). It is the product of the development of the Wechsler-Bellevue intelligence test, which was created by David Wechsler, the Chief Clinical Psychologist at New York City's Bellevue Hospital. As the test's name implies, it is intended primarily to measure "intelligence", i.e., to provide an accurate estimate of the examinee's overall mental ability level. The WAIS score which states that estimate is called the Full Scale Intelligence Quotient (FSIQ). However, extensive research has shown that certain patterns among the WAIS's scores are related to the presence of clinical problems, such as neurosis and psychosis. The WAIS scores can therefore yield far more types of hypotheses than just mental ability estimates, especially when those scores are augmented by the clinician's observations of the examinee during WAIS

administration and by reliable background information.

.   It   supposedly takes about one and one-half hours to
administer the WAIS, and about another one and one-half hours to
score and interpret it, if more than an ability estimate is
desired.   If that second one and one-half hour period could be
reduced without sacrificing accuracy, that would benefit both the
clinician and the examinee.

If a computer software system which could relieve the
clinician's burden could be created, that system could be made to
satisfy the above requirements.   Since evaluation of the WAIS is
definitely an intelligent behavior,   the use of Artificial
Intelligence (AI) techniques could be used to create such a
system.   The entire evaluation process would have to be
algorithmic and the expected data input precisely known before
algorithmic techniques could be used for that system's creation.
WAIS evaluation as a task does not meet those requirements, since
the data cannot be precisely known before input, nor can all
possible paths which an algorithmic program might take be
determined.   Also, there may be changes in what the system
"knows", both in domain knowledge and in the ways in which it
handles the data supplied to it.   In addition, the data take a
variety of forms.   Some of it will be numerical, such as test
scores, and some will be lists of words.   Algorithmic languages
fall short in list-handling capability.   Some way to implement
the system is needed which can accomodate the above requirements.
LISP is a language which was created to handle lists, and AI
techniques are the most promising way to fulfill the software
system requirements.

One problem with designing such a software system is the acquisition of domain knowledge. I already had some familiarity with the field of psychology, and therefore knew of two books which were extremely rich sources of clinical information about the WAIS. I also needed a human expert to fill in what those books could not offer, and was fortunate to secure the assistence and cooperation of Dr. Robert Sinnett, a practicing clinical psychologist in the Manhattan, Kansas area. Dr. Sinnett has practiced for many years, and enjoys the esteem of his Kansas colleagues. At the time of this report, he was a member of the Kansas Board of Mental Health Examiners, the group which determines who will (and will not) practice clinical psychology in Kansas.

I interviewed Dr. Sinnett a number of times, seeking to obtain the knowledge and insights which can only come from years of clinical experience. Since a human experts seem to be very efficient at finding solutions to problems very quickly, I was particularly interested in the particular data which would make a clinical entity a very distinct possibility ("superqualified") or reduce the probability of its presence to practically zero ("disqualified"). Dr. Sinnett told me about those data for all of the clinical entities which DAVE will know about. He also supplied some more of the clinical observations which psychologists look for in examinees, and the relationship of those observations to the clinical entities. We also discussed the types of activities which people with each of the clinical entities tend to do well and those which they tend to do poorly. Dr. Sinnett also told me about the abilities which are necessary

for a high score on each part of the WAIS, and gave me some concrete definitions for some of the terms in the books I also used for sources of information.

The two books alluded to previously offered information in slightly different ways, and each has certain strengths and inconveniences. Ogdon (1977) limited himself to exclusive concentration on the possible meanings of single WAIS test score patterns, but also gave his work two compensating strengths. First, it covered a wider variety of mental disorders and the behavioral or emotional phenomena which accompany those disorders. Second, each possible mental disorder and behavioral or emotional phenomenon discovered to be present in people whose WAIS test scores by clinical research was rank-ordered with the most common disorder or phenomenon given first. Gilbert (1978), the other major printed information source, offered combinations of test score patterns and test score patterns combined with other types of evidence which are frequently available to clinicians. However, the problems associated with each set of evidence was not explicitly rank-ordered, and there seemed to be no listing of one major type of mental disorder. The combined information offered by the two books was extremely valuable, however.

Knowledge Domain Background

This section describes the domain in which DAVE will operate. The three types of information DAVE will use are described and their relative importance is given.

Clinical Psychology and Testing

DAVE will be operating in the domain of clinical psychology, that branch of psychology which most often deals directly with people who are mentally troubled. There are a number of professions which also work with mentally troubled people, the two other major ones being psychiatry and social work. A clinical psychologist can administer psychotherapy, but cannot dispense psychoactive drugs, as can a psychiatrist. One of the major parts of a clinical psychologist's work is the administration of psychological tests. There are a wide variety of psychological tests which a clinical psychologist could use, but some tests are used far more frequently than others, and the WAIS is one of them. It is usually advisable to administer some tests before others. For example, an intelligence test, such as the WAIS, is usually given before any tests which directly and more obviously attempt to obtain emotional material from a client. The WAIS does not require the client to actively fantasize, as do the Rorschach Inkblot Test or the Thematic Apperception Test. The WAIS, therefore, is usually one of the first tests administered. At that point in the evaluation, the clinician's primary effort is the generation of hypotheses about the client, and those hypotheses are investigated later in other tests or interviews. Therefore, any implications about the client arising from the evidence available from the WAIS and

other sources at that point in a psychological evaluation should be regarded as tentative hypotheses, subject to later confirmation or rejection.

As should be evident from the above description of the clinical psychologist's testing efforts, the clinical psychologist, whether in a public institution or private practice, faces enormous pressures. Evaluation of WAIS scores and other testing may well be only a small part of the psychologist's duties. Many psychologists do psychotherapy as well, and they need to be able to spare some mental and emotional energy for that. Therefore, a tool that could assist a clinical psychologist with the more routine parts of clinical practice should be welcome, but it must be not force the clinical psychologist to sacrifice quality of evaluation for speed. Such a sacrifice would be grossly unethical to most psychologists. Only a tool of the highest quality would stand a chance of acceptance by the clinical psychological community, and that is exactly how it should be.

Three types of evidence will be used in DAVE, and those are the WAIS scores, the clinician's observations during testing, and background information. Although this system nominally revolves around the WAIS, the observations are considered to be the most important and reliable type of information. WAIS scores are the second most important, and background information is considered the least important. The relative importance of each bears directly on DAVE's design, as we shall see.

The WAIS is usually one of the first tests given by a clinical psychologist to an examinee. Background information may

or may not be available immediately after testing. During WAIS administration, the clinician not only records test responses, but also reactions to the various demands placed on the examinee by the specific content of the tasks to be performed, the testing situation in general, and the interpersonal processes involved.

The WAIS

Table 1

The Subtests of the WAIS

Verbal Subtests	Performance Subtests
Information	Picture Completion
Similarities	Picture Arrangement
Arithmetic	Block Design
Vocabulary	Object Assembly
Comprehension	Digit Symbol
Digit Span	

As shown in Table 1, the WAIS is composed of 11 different subtests, and those subtests are arranged into two groups. The Verbal subtests, which are all consist of questions asked by the clinician and answered by the examinee. The Performance subtests all ask that the examinee look at something and react to it in some way. Most of the subtests require the examinee to manipulate physical objects. It seems, then, that the Verbal subtests measure verbal abilities, and the Performance subtests measure visual and visual-motor abilities.

The types of questions asked by the examiner during each of

the Verbal subtests differs. The Information subtest consists of general-knowledge questions, such as "What colors are found in the American flag?". In the Similarities subtest, the examiner gives the examinee the names of two different things that have something in common, and the examinee is expected to tell how they are alike. A typical Similarities question would be "How are a wheel and a ball alike?". Arithmetic consists of relatively simple arithmetic problems which are presented orally by the examiner and answered orally by the examinee. Pencil and paper are not allowed; the examinee must calculate mentally. The Vocabulary subtest consists of the examiner saying a word from the list of selected words, and the examinee replying with a definition of the given word. The Comprehension subtest is something of a mixed bag of questions, with some of the questions appearing to test common sense and others appearing to have a rather strong moral component. An example of a Comprehension question testing common sense would be, "If you were lost in a forest, how would you find your way out?". An example of a Comprehension question with a moral component would be, "If you found a letter on the street which was addressed and had a new stamp on it, what would you do with it?". The two parts of the Digit Span subtest are called Digits Forward and Digits Backward. In Digits Forward, the examiner presents a series of random digits at the rate of one digit per second, and the examinee is asked to repeat them in the presented order. In Digits Backward, the examinee is asked to repeat the numbers backward, i.e., in reverse order.

The types of tasks in the Performance subtests also differ

from one subtest to the next. In Picture Completion, the examinee is shown a series of pictures, one at a time. Each picture is a drawing in which something has been omitted. The examinee is asked to either tell what is missing or point to the area of the picture where the missing object would be if it were present. Picture Arrangement resembles a series of cartoons with the pictures cut apart. The pictures in each series are presented to the examinee in scrambled order, and the examinee is asked to rearrange them into the correct order. In Block Design, the examinee is first shown how to make a pattern with the blocks supplied with the test kit, and then makes that pattern with a set of similar blocks. Shortly thereafter, the examiner shows the examinee a picture of a design that can be made with the blocks, and the examinee is expected to construct the design. The rest of the subtest proceeds with the examiner showing a picture of a pattern which can be made with the blocks and the examinee attempting to construct that pattern. In the Object Assembly subtest, the examinee is asked to assemble four puzzles.

Digit Symbol is the only subtest which uses pencil and paper. There are two major sections printed on the Digit Symbol form, the key and the body. The key, which consists of two rows of boxes, is at the top of the Digit Symbol form. The digits 1 through 9 are in the top row, one digit per box. Below each digit is the symbol which the examinee is supposed to write under that digit in the body of the test. The body of the Digit Symbol subtest consists of several lines of connected boxes, with two rows of boxes in each line. In the top row of each line, each box has one digit. The lower boxes in each line are

blank and vertically paired with a digit in the upper row. The examinee is expected to put the symbol in the box below each digit that matches that digit. The examinee is allowed to look at the key as often as desired.

All of the Performance subtests are timed. Arithmetic is the only Verbal subtest that is timed. On all timed subtests, there is a time limit for each item. Bonus points are given for rapid accomplishment of some of the timed items.

The WAIS yields a number of scores. There is one score for each subtest, and three different Intelligence Quotients. The Verbal Intelligence Quotient (VIQ) is a composite score, calculated from the total of the Verbal subtests, except for Digit Span. The Performance Intelligence Quotient (PIQ) is a similar composite of all of the Performance subtests. The FSIQ is a composite of all of the subtests except Digit Span. The two parts of Digit Span, called Digits Forward and Digits Backward, are frequently considered separately.

Since each subtest is different from all of the other subtests, each one is considered to be a measure of a unique combination of abilities. However, there are some common factors which affect performance on different groups of subtests. For example, Arithmetic, Digit Span, and Digit Symbol all require considerable concentration. Therefore, if those three subtest scores are low when compared to the other subtest scores, the clinician could reasonably hypothesize that the examinee has difficulty with concentration. That difficulty, if present, could be explained by several different other hypotheses. Organic damage to the brain, severe anxiety, and other

possibilities might suggest themselves. Other evidence would have to be considered to determine which of those other hypotheses is the most likely. That other evidence could be observations during those three subtests, other test score patterns, or background information. Clinical research has discovered many other subtest combinations, each of which suggests the presence of more than one quality or clinical entity in the examinee.

Observations

Observations of the examinee's behavior during testing are the most important type of evidence among the three types. They are done by the clinician, not by someone else, which means that the clinician does not have to depend on someone else for the information. Observations also have the advantage of being recorded after the client is aware that the evaluation will occur. By contrast, the background information gathered on the client, even if it is accurate and relatively complete, reflects the client's past, before awareness of the evaluation and its possible subsequent outcomes. In a certain sense, then, observations may have stronger implications for the client's future. Also, observations lend themselves to more general conclusions than test scores do; they are a richer source of hypotheses for future investigation. In fact, the WAIS itself might be considered a series of standardized tasks which afford the clinician the opportunity to observe the examinee, with the obtained numerical scores being almost an added bonus.

Observations are especially important for the task that DAVE will attempt to perform, since the approach which is taken to a

task and the motor and verbal behaviors during the attempt at a task suggest far more to a trained clinician than the entire set of scores obtained. For example, the examinee's reaction to the Comprehension subtest questions which have a degree of moral flavor can reveal how that examinee reacts to moral questions in general. If the examinee reacts to such questions by ignoring their moral implications, makes fun of those implications, or gives the examiner a response which is very high in moral content, but seems covertly contemptuous of moral issues, then the antisocial personality disorder is a distinct possibility.

Background Information

Background information, which may also be called "social history", is a collection of useful information about the examinee's past. It would include information which might be significant in assessing how well the examinee coped with life. Information about the examinee's education, employment, marital status, military service, and police records would all contribute to this body of information. People who knew the examinee, such as a spouse, co-worker, past or present employer, or teacher, might also be interviewed. From the clinical psychologist's viewpoint, this background information is a problem. It may not be available in usable amounts, or even at all. It is usually gathered by someone else, whom the psychologist may not know very well. The informant may not be reliable or may be biased toward the client in some way. The clinical psychologist frequently does not meet that informant, which adds a further unknown element to the background information. For all those problems, however, some knowledge of the client's background is certainly

much better than none. That *information puts a perspective* on the test scores and clinical observations that cannot be obtained otherwise. So, background information is considered, but is considered to be less reliable.

The synthesis of hypotheses from WAIS scores, observations during WAIS administration, and reliable background information is a demanding task. Any given piece of evidence, taken in isolation, may imply several different things about the examinee. Some of those implications are higher-order clinical entities, such as neuroticism, psychoticism, giftedness, organic brain syndrome, antisocial personality disorder, or mental retardation. Others are *more minor* aspects of an examinee's mental state. These more minor aspects include, but are not limited to, general or situation-bound anxiety, depression, a vacant stare, constant repetitive movement, tics or other jerky movements, an utter lack of concern about obvious failure of even the simplest tasks, too much concern about failure of more demanding tasks, failure on easy test items with passes on more difficult ones, bizarre utterences, bizzare associations with some of the test items, very high or very low overall activity level, energy level and volume of the voice, general speed of response and whether that speed changes under a variety of circumstances, attitude toward the examiner, attitude toward authority figures in general, any attempts at cheating, worry about what the examiner might be writing on the test form, great concern about being timed on the timed subtests, inability to make simple decisions, overly-long reponses or overly-short responses, overall quality of responses, any blatant specific problems in speech or movement, any tendency

to try to cover an inability to respond correctly, and any grossly inaccurate response in the middle of a group of accurate ones. These minor aspects may be related to one or more clinical entities. Also, each type of evidence has its own basic reliability or degree to which it can be trusted.

Clinical research could change the ways in which the WAIS is used. Since the WAIS is one of the most commonly-used tests in clinical psychology, it is the focus of a number of research efforts. Also, the WAIS has recently been revised, and there will probably be studies to compare the clinical aspects of the revision to the older version. It is obvious that the clinical analysis of the WAIS is, in itself, demanding. It is made more so by the changes which have been and will be brought about by continuing research. New relationships between raw information and the conclusions made from that information will probably be found. New methods of analysis may be found as well. Add the repetitve occurrence of WAIS analysis to these difficulties, and it becomes apparent that computerization of WAIS analysis could be very welcome to the clinical psychology community. As will be seen in the next two chapters, artificial intelligence (AI) techniques are the most promising way to computerize this task.

Knowledge Engineering

This . chapter defines and discusses some knowledge engineering issues. The relationships among AI, expert systems, and knowledge engineering are described. Also, some relationships between suggested coping methods for knowledge engineering problems and DAVE's design are mentioned.

Human and Machine Intelligence

The nature of "intelligence" has been and remains one of the most perplexing questions which human beings have ever faced. It seems to bear upon the ability of an organism to learn things and to adapt to its surroundings. It has usually been perceived as a single factor, meaning that it may be measured and the results of the measuring expressed as a single number. There have been numerous objections to the single-factor notion of intelligence, and these objections have occurred in both theory and practice. The WAIS, for instance, yields three intelligence quotient scores, one of which purports to estimate the examinee's global intelligence. However, it also gives separate estimates of an examinee's verbal ability and visual-perceptual and visual-motor ability. Gardner (1983) has objected to the notion and use of the unitary intelligence concept, and proposed in its stead a notion of multiple intelligences. Those multiple intelligences consist of bodily-kinesthetic, linguistic, logical-mathematical, musical, personal, and spatial intelligences.

The biggest problem with the notion and measurement of human intelligence is that human beings are so flexible and have so many abilities. The human brain, if reasonably intact, could be regarded as true computing marvel. It does not possess the

computation speed of silicon-based computers, but can make inferences and make decisions in the presence of inadequate data. It can also create completely new ideas and works of art. It seems to have the disposition to learn certain types of things at certain points in its maturity. Children of ages 5 to 10 years already have a great deal of "common sense". I believe that "common sense" is a gross misnomer, since it is anything but "common". In all of the known Universe, there is only one species which develops it. It is the product of the most radical and rapid learning process known. It is formed in a place which is predisposed to form it. It is also one of the most frustrating types of knowledge to try to give a computer.

Knowledge Engineering and Human Expertise

At present, the machines which we would endow with intelligence are very limited, compared to the human brain. We are therefore forced to choose which subset of human ability we would put into such machines. Before we can do that, we must know what kind of data that ability subset must handle, and how it handles it. The most common subsets of human abilities which are presently being put into computers are expert systems and the AI subdiscipline which designs those systems is knowledge engineering.

Stefik et al. (1983) used Feigenbaum's (1977) definition of knowledge engineering, as follows:

The knowledge engineer practices the art of bringing the

principles and tools of AI research to bear on difficult

applications problems requiring experts' knowledge for their

solution. The technical issues of acquiring this knowledge,

representing it, and using it appropriately to construct and explain lines-of-reasoning, are important problems in the design of knowledge-base systems...The art of constructing intelligent agents is both part of and an extension of the programming art. It is the art of building complex computer programs that represent and reason with knowledge of the world.

What, then, is human expertise? What makes an expert an expert? A human expert possesses a great deal of knowledge about a relatively small portion of human endeavor. That knowledge is partly academic and partly experiential. A knowledge engineer must determine the cognitive composition of human expertise in a field of endeavor. That determination is made by interviewing one or more experts and from reflecting upon what those experts say and show. A knowledge engineer would have to answer numerous questions about a field of knowledge: How does the expert begin to handle the task; what is done first? What data are sought first? What data are sought after that, if any? What form do these data take? How certain are the data? How complete are the data, does the human expert ever have to make decisions without adequate data? If the expert cannot be certain of the data or the data are incomplete what is done to compensate for that uncertainty or incompleteness? Does each piece of data always suggest just one conclusion or several conclusions? Does one piece of data ever tend to confirm other pieces of data, or contradict other pieces of data? What is done to handle the tendency to confirmation or contradiction, if one exists? Can the final conclusions be drawn directly from the data or do

intermediate inferences have to be made first? If intermediate inferences have to made first, how many levels of those must be made before the final conclusions? Does the expert reason forward from the data to conclusions or backward from a set of conclusions to the data or some combination of forward and backward? Is the same line of reasoning always used or several lines of reasoning? If several lines of reasoning are used, what are they and under what circumstances is each of them used? If the conclusions reached by different lines of reasoning are different, how are the conflicts resolved? How certain are the intermediate or final conclusions? If conclusions are less than absolutely certain, what is done to rate the degree of certainty? Is there some minimal level of certainty which is acceptable, and if so, what is done when that certainty level drops below acceptability? Finally and most importantly, can the answers to these and many other expertise-related questions be represented in a machine-readable form, and if so, how?

Expert Systems

Numerous expert systems have now been built, and they have certain architectural features in common. Let us see what is needed in an expert system, and what architectural feature meets those needs. First, some way to store the expertise obtained from a human expert is needed. That expertise is put into the knowledge base, frequently in the form of rules. Those rules usually have at least an implied "if...then..." structure, if not an explicit one. Another needed feature is a place to put all of the information which is relevant only to the case which is under consideration. This part might be called the working memory, and

it would contain such things as recorded observations, numerical data or readings, test scores, and so on. Some system for weighing the confidence in the conclusions reached by the system would also go into working memory. Finally, we need something to tie the knowledge base and the working memory together, and that part is the control system. The control system would obtain data from the user, process the data if needed, and store it. It would also have any menus or list of questions used to interface with the user. In addition, it would evaluate the rules in the knowledge base to see if they apply to the case under consideration, and would also select stored data or other evidence for consideration.

There is an infinite variety of expert systems which could be built, but the structure of each system is partially determined by the nature of the problems it works on. Stefik et al. (1983) described the necessary architectural features of expert systems required to cope with various problems in the data, knowledge, and solutions of such systems. The simplest possible system to create requires there be relatively few solutions, that the data be reliable and fixed over time, and that relatively little knowledge is required to work with that data. For such a system, the knowledge can be searched exhaustively, a single line of reasoning can be used, and the amount of reasoning required does not change with the amount of available data. The given requirements are very stringent, and if they cannot be met, additional features must be designed into the expert system to cope with them. Stefik et al. (1983) specified such additional features. There are ten types of

problems given, and a discussion of all of them is outside the scope of this paper. Only one of the problems applies to DAVE, and that one is unreliable data or system knowledge.

Overcoming Unreliable Data

Probability Models

Stefik et al. (1983) prescribed combining evidence from multiple sources, probability models, fuzzy models, and exact models as ways to cope with unreliable data or system knowledge. Probablility models were first used to overcome the problem of incomplete or unreliable data. The expert system most associated with the probablity model is that first one, MYCIN. The probability model was used in MYCIN like this: The rules in the knowledge base were set up in the approximate format:

If all conditions in this rule are met

Then there is a degree of certainty, expressed as a

number between -1 and 1, that some conclusion is

true for the case under consideration.

In MYCIN, a degree of certainty of "-1" meant "definitely false", that the conclusion was not true, and a certainty of "1" meant the exact opposite. A degree of certainty is not the same as a probability. Degrees of certainty are the product of Bayes' Rule.

MYCIN used Bayes' Rule to arrive at degrees of certainty, and Bayes' Rule has some serious disadvantages. The main problem is that considerable detailed research is needed to assess the degree of certainty between each of the steps in the chain of reasoning in which the Rule is being used. A chain of reasoning in any given case is only one possible path of many paths which might be followed. Picture a tree data structure, with each

interior node having an average of four children. Each node is a machine state after a step in the inference process, and each arc a pathway from one machine state to the next. The root node is the machine state at the beginning of the inference process, and each leaf is a possible conclusion which could be drawn by the inference process. If there are, say, 30 nodes in a reasoning chain, that means that degree of certainty between each node involved in the chain will have to be known before Bayes' Rule can be applied correctly - to that particular chain. If all of the nodes in the chain are to be truly useful, all of the certainty factors for each arc descending from each node must be known. If the deepest leaf node was 100 levels from the root, any attempt to tune such a system would be extremely time-consuming.

I object to Bayes' Rule on another ground: I do not believe that it is a very good model of a human expert's conscious reasoning. A human expert might possibly be unconsciously manipulating certainties or probablilities while considering the data in a case, but I doubt it. At present, human expertise is impossible to imitate, since the working of the human mind is still a mystery. Researchers in AI and cognitive psychology are trying to discover the nature of thinking processes. At present, those researchers seem to be concentrating their efforts on specific cognitive strategies, rather than upon trying to bring what has already been found into a coherent whole. As Dennett (1981, pp. 110-111) put it:

> Faced with the practical impossibility of answering the empirical questions of psychology by brute inspection, (how in fact does the nervous system accomplish X or Y or Z?),

psychologists ask themselves an easier preliminary question:

> How could any system (with features A, B, C,...)
> possibly accomplish X?
>
> This sort of question is easier because it is "less empirical"; it is an engineering question, a quest for a solution (any solution)...[all emphases Dennett's]

One could say, then, that we are not even sure that we have all of the important pieces of the cognitive puzzle, let alone the entire picture. Therefore, emulation of human cognition is the best we can do.

Fuzzy Logic

Fuzzy logic is another interesting method for reasoning with unreliable data. It takes the form of a combined fuzzy proposition and fuzzy set, such as this one adapted from Stefik et al. (1983):

> Fuzzy Proposition: X is a large number.
>
> Corresponding Fuzzy Set: X is between 0 and 10, .1
>
>   X is between 10 and 1,000, .2
>
>   X is more than 1,000, .7

The interpretation of the above is as follows: Given that X is a large number, the possibility of X being between 0 and 10 is 0.1; between 10 and 1,000, 0.2; and more than 1,000, 0.7. All possibilities are the given decimal out of 1.0.

As with certainty factors, fuzzy logic gives the impression of precision that only numbers can give. But there are also the same types of problems as there were with certainty factors. Fuzzy logic uses a single proposition and supplies several alternatives, assigning probabilities for each alternative. It

would be a good method if the expert system's rules could be set up with such a structure. However, each piece of data in DAVE is not in itself a proposition, but a single piece of evidence which could provide support for more than one conclusion. Also, clinical psychological researchers have not seen fit to attempt to express their results in such a fashion.

Exact Models

Stefik et al (1983) also prescribed exact models as another way to handle missing data. In the given example, missing data could be corrected. Briefly, the given example system was GA1, an expert system which assembles models of complete DNA structures, and the data were the pieces of DNA structures. Those pieces of a complete DNA structure were the products of the action of digestive enzymes upon an intact DNA structure. There were times that some of the possible molecules which were the product of a complete digestion for an enzyme did not appear in the data, and the GA1 system could adjust for the missing data by adding the products of a complete digestion for an enzyme into the data. In that particular problem, then, there were sets of data which could be expected to appear, given the enzymes which were used. That is not the case with DAVE. One piece of data supplied to DAVE does not suggest the presence of other data. Exact models, then, although useful, would not appear applicable for DAVE.

Combining Evidence From Multiple Sources

Stefik et al. (1983) also mentioned combining evidence from multiple sources as a way to deal with unreliable data or knowledge. It so happens that there is another problem which

DAVE must cope with, that being the excessive weakness of a single source of data. Gilbert (1978), one of the principle sources of the domain knowledge in DAVE, does, in fact, combine data from multiple sources. That combination of sources was used to set up the knowledge base in DAVE.

Benefits and Costs in Expert Systems Creation

The creation of an expert system requires considerable effort and time, so there should be fairly pressing reasons for the expenditure of that effort. One such reason is the reason that many computer software systems are created, the relief of humans from repetitive tasks. Expert systems are also created to relieve the effects of shortages of human expertise in given knowledge domains. These shortages can be in both the knowledge possessed by each existing human expert and the number of human experts. An expert system can be engineered to reflect the combined knowledge and experience of several human experts, then made available to anyone who needs that combined expertise. If it would be possible to train paraprofessionals to use the expert system and that system could be made available to them at the physical location where the expertise is needed, then they could do the more routine analyses or jobs. This would enable the human experts to do only the more demanding tasks. It might also enable those human experts to do the research which they would not have had the time to do before implementation of the expert system. Thus, a previously-impossible synergy would occur: The human experts would be able to advance the knowledge within their field, feed that new knowledge into the expert system, and return to research even further. In summary, expert systems have the

possibility to make the computer do more of what it was invented to do in the first place: Free human beings for those activities which only human beings can do.

System Design

This chapter describes DAVE's specific design. In addition to the textual top-level description and sample run description, a diagram of the entire system is provided on the next page. The most complex part of the system is the inference engine, and the algorithm for it is given in Appendix D. A diagram of the inference engine is given in Appendix E.

DAVE is designed to automate a portion of a human expert's routine work. Given that, it is obvious that DAVE should be easy to use and run fairly quickly. As a part of the effort to make DAVE easy to use, a considerable effort was made to compensate for entry errors. This compensation was done by giving the user a second chance to make choices from menus, informing him if an entry error was made and that he could try again, and giving him feedback after the system required several consecutive entries from him. DAVE is also designed to be able to incorporate new research findings in the clinical psychology domain. That new knowledge can be incorporated into DAVE's rule set.
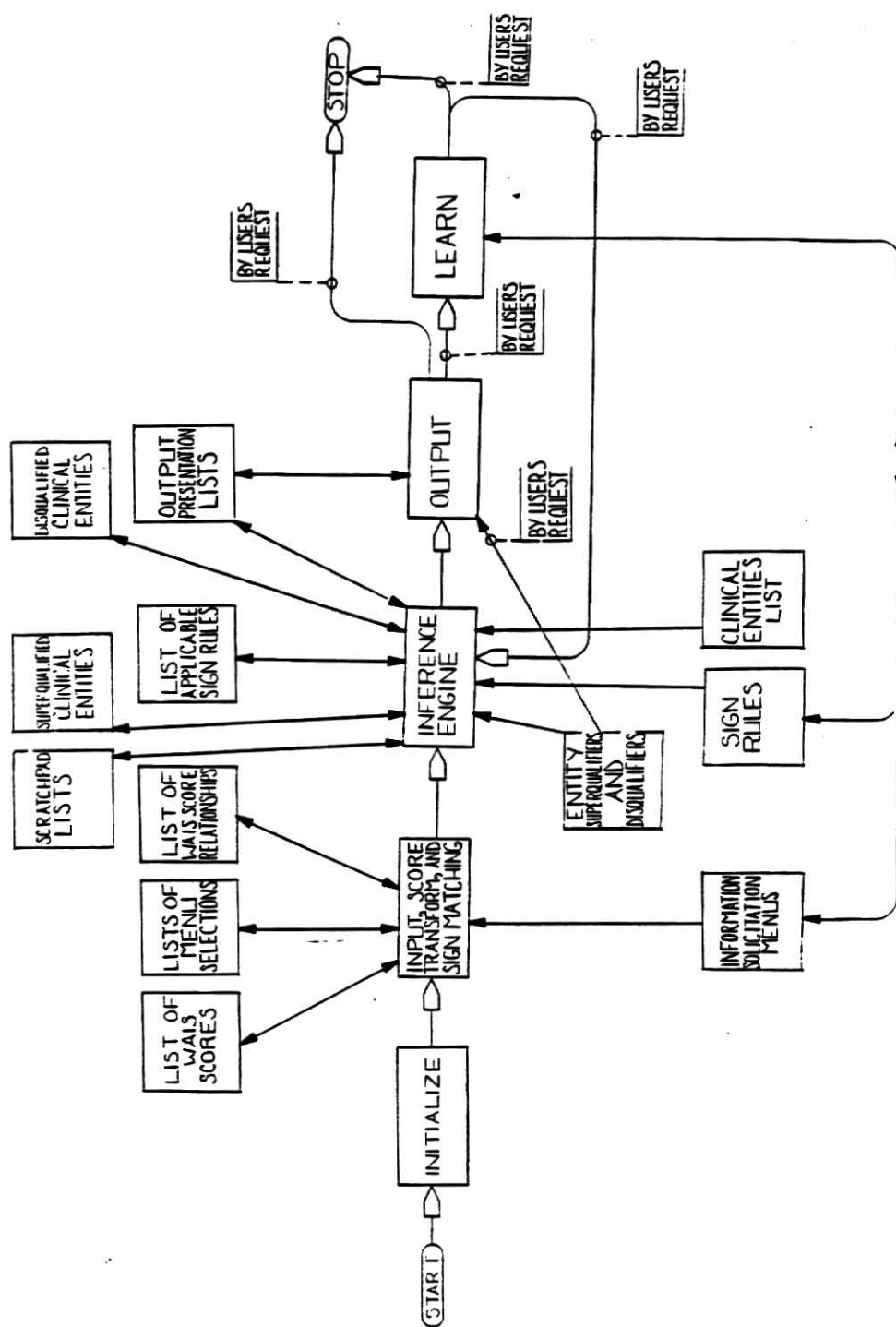
The Rule Set

DAVE's rule set now has 146 rules. All of those rules are listed in Appendix A, but here are a few examples:

```
(rule075
  (score (greaterp bd (plus pmean 2)))
  (test-retst (greaterp piq1 piq2))
  (hypothesis01
    (main (qualifier none) (paranoid schizophrenia))
    (secondary none)
    (additional none))
)

(rule091
  (observe (and (3 E)(3 L)) )
  (score (and (greaterp bd (plus pmean 2))
              (greaterp oa (plus pmean 2)) ) )
  (hypothesis01
    (main (qualifier none) (acute paranoid schizophrenia))
    (secondary none)
    (additional none))
)

(rule116
  (score (and (lessp s (difference vmean 2))
              (lessp a (difference (vmean 2)))))))
  (certain (schizophrenia))
  (hypothesis01
    (main (qualifier none) (chronicity))
    (secondary none)
    (additional none))
```

```
)

(rule118

  (score (and (greaterp i 10) (greaterp cm 10) (lessp s cm)

             (lessp v (difference cm 2)) (greaterp i (plus s 2))

             (greaterp i (plus v 2)) ) )

  (bckgrnd (5 J))

  (hypothesis01

    (main (qualifier none) (intellectual striving))

    (secondary none)

    (additional none))

)
```

The common features may be seen from an examination of the above rules. The very first line of each rule is the rule number. The second line is one of the categories of evidence, and the category is specified by the first word on the line. If the first word is "score", then the evidence which follows is a WAIS score pattern. If the first word is "observe", the evidence is an observation made by the psychologist during testing. That observation is not spelled out, but refers to one of the selections from one of the input menus. In the example above, the observations were coded "(3 E)" and "(3 L)". Both of those observations would be selected from the third input menu and would stand for "inertia" and "inability to concentrate on [the] Arithmetic [subtest of the WAIS]", respectively.

Other categories of evidence are "bckgrnd", "certain", and "test-retst". The "bckgrnd" category items are also menu selections. In the example shown above, "(5 J)" appears as a piece of background information in rule number 118. Item "J" on

input menu number 5 means "restricted formal education". If the psychologist were to select that item, that would mean that the examinee's formal education was not very extensive. The "test-retst" category is a statement of the relationship between WAIS scores from two separate administrations of the WAIS. In the above example, the Performance IQ was better on the first WAIS given to the examinee than on the second one. The last evidence category found in the rules is "certain", which requires special treatment for the rule in which it appears. By itself, "certain" means that the system has weighed all of the other evidence and has found that the clinical entity given after the word "certain" is very likely to be present. In the example given above, the clinical entity which must be very likely to be present before that rule is fired is the very serious mental illness called "schizophrenia". If the examinee is determined to be likely to have schizophrenia, then the schizophrenia is likely to be chronic, rather than acute.

The hypotheses associated with each piece or combination of pieces of evidence follow the evidence specification in each rule. In each of the example rules shown, each rule has only one hypothesis. That need not be the case; some of the rules have eight or more hypotheses. There are three parts to each hypothesis, "main", "secondary", and "additional". The "main" part of an hypothesis is the major part of it, and may be preceded with a qualifier of some kind, such as "probably" or "possibly". The "secondary" part of each hypothesis is an elaboration of the "main" part. For example, if the "main" hypothesis were "paranoid schizophrenia", the "secondary"

hypothesis might be "chronic paranoid schizophrenia". The "additional" part of the hypothesis is another piece of evidence which tends to make the "main" or both the "main" and "second" hypotheses more likely. The latter is illustrated by the partial rule which follows:

```
(rule011

  (score (greaterp ds (plus vmean 2)))

                    .

                    .

                    .

  (hypothesis03

    (main (qualifier possible) (schizophrenia))

    (secondary (qualifier perhaps) (simple type))

    (additional (ds > v + 2))

      (enhance (main secondary)))
```

Processing - A High-level Description

At the highest level of description, DAVE's many functions will be divided among five modules. They are Initialize, Input, Inference Engine, Output, and Learn. The Initialize module is used only if DAVE is run more than once. It selectively erases the specific bindings for the previous case that DAVE processed. The Input module receives the user's input and does some preliminary processing to prepare for the Inference Engine. The Inference Engine functions discover any clinical entities which are either very likely or very unlikely to apply to the WAIS examinee, then examines for clinical entities whose possible presence or absence is much less certain. While the Inference Engine is running, it deposits the conclusions that it makes and

the steps taken to reach those conclusions into output lists. The Output module simply displays the lists of conclusions and, by user request, the steps taken to reach those conclusions. Normal use ends there. If another case is to be run, the processing would go to the Initialize module. If, however, the user believes that the system can be improved, the Learn module can be invoked. This module enables the user to access and modify some of the major "data structures" in DAVE.

The reason for the quotation marks around "data structures" is that there are certain structures in DAVE which are primarily data structures, but which also manipulate other data. The ability to do this within the same structure is part of the attraction that the LISP language holds for AI people. Everything in LISP is a list, and only a list. Data and program do not have to be distinct, and I found it advantageous to embed certain functions within the "data".

DAVE can best be described in more detail by relating how it is used. When DAVE is run, all of its files are first loaded into the combination of LISP interpreters described above. Since this is the first case that DAVE will handle since loading, no re-initialization occurs, i.e., the Initialize module is not run. The user is presented with a menu requesting information on the WAIS scores. Since DAVE can handle a situation where a WAIS was given before the present WAIS, the first piece of information requested is whether this run will involve one set of WAIS scores or two sets. If there are two sets of WAIS scores, the user is then asked if the scores from the previous WAIS or the scores from the WAIS just given will be input first. If there will be

only one set of scores, the menu which specifies the order of score input is presented. After the last score is input, the user is shown all of the scores and asked if any changes need to be made. If so, those changes are made. If not, input processing continues. If there are two sets of scores, the score input menu is presented twice, once for the previous WAIS and once for the present WAIS. The user is given the opportunity to make any changes or corrections after both sets of scores have been input.

Processing then proceeds to the presentation of the menus for background information and test observations. Each menu presents about 12 observations or pieces of background information. Each menu item has a letter preceding it. If one or more of the menu choices were true for the examinee, the user selects those choices by pressing the key on the terminal keyboard which corresponds to the letter preceding that item. When the user has selected all of the applicable choices from a given menu, he presses another key to indicate that all of the applicable selections from that menu have been made. The menu items which have been selected are then displayed for possible additions, deletions, or modifications. If none are necessary, the user indicates so. If changes need to made, they are made immediately, before the presentation of the next menu. The input process continues in this manner until all of the menus have been presented and the user has made all of the applicable choices. An indication of the end of the input process is then shown to the user, and the bulk of the processing begins.

While the user was still making choices from the different

menus, a list of encoded menu selections was made, with each
item on that list consisting of a menu's number, the selector key
for the chosen menu items, and the text of the item. Using the
above example, the list being created might look like this:

      ((2 B Failure of easy Picture Completion items)

      (2 K Evidence of apprehension)

      (3 A No schizophrenic verbalizations)

      (3 E Inertia))

This new list is made for output and explanation of Inference
Engine processing. After that, processing transfers to the
Inference Engine module.

The Inference Engine first attempts to find the clinical
entities which have an extremely high probability of being
present in the WAIS examinee (superqualifiers) and then those
which have an extremely low probability of being present in the
examinee (disqualifiers). These are found by searching a data
structure which lists the super-qualifying and disqualifying
evidence for each of the clinical entities. Some of the clinical
entities have more than one set of super-qualifying evidence or
disqualifying evidence, and some have an empty set for one or the
other type of evidence. All of the evidence in a set must be
present for the clinical entity to be considered super-qualified
or disqualified. If one type of evidence, such as background
information, is missing, then the set is considered to be
incomplete, and super-qualification or disqualification will not
occur. During this processing, additions are being made to a
list of inferences which the system makes during the running of
the Inference Engine. That list is made for explanation of the

Inference Engine processing, should such a list be requested by the user after completion of output.

The bulk of the Inference Engine's processing is done to consider those clinical entities which are not super-qualified or disqualified in the process described above. The likelihood of a clinical entity's presence or absence in the examinee hinges on the relative strength of the evidence supporting the presence hypothesis. There is a heirarchy of evidence reliabilty among the three types of evidence, which are WAIS scores, observations, and background information, in order of decreasing reliability. This processing works with the sign rules. For example, the signs portion of a rule might specify that the WAIS Information subtest is low, that background information suggests a lack of normally-expected educational opportunities, and the observation that the examinee seemed to be fairly embarassed when unable to perform the tasks expected of him. The hypotheses for such evidence might be "lack of educational opportunities still affects the examinee", "rule out mental retardation", and possibly some others. This rule would be used only if all of the evidence specified in the signs portion were true for the examinee.

The "certain" part of the evidence becomes significant later. Sometimes, when a given clinical entity, such as psychosis, is known to be present, examination of the evidence can yield additional hypotheses which may be useful for further investigation or therapy. At this point in the Inference Engine run, the "certain" portion of the evidence is not used, because all of the possible clinical entities which might be present are not yet known.

The sign rules described above are searched exhaustively and put into a list. Then, the observations portion of the rules are considered to see what conclusions would be reached by virtue of the observations alone. After that, the WAIS score relationships are considered in the same fashion. The background information is considered last. The conclusions reached for each type of evidence is then compared. If the conclusions from all types of evidence is the same, then those conclusions are put into an output list to be fed back to the user. If the conclusions are not the same, the conclusions from the test observations are given priority over the others. If, for example, processing of the observations conclude that psychosis is the most likely clinical entity to be present in the examinee and the processing of the WAIS scores concludes that organic brain syndrome is the most likely entity, but that psychosis is the second-most-likely enitity, then DAVE will conclude that the most likely clinical entity is psychosis, with some evidence also suggesting organic brain syndrome.

A Sample Run

The design might best be illustrated in more detail by a sample run of a case. Here are the data for the run:

Background Information

The examinee, a 27-year-old white male, was referred by the court, and is presently facing charges of fraud. He has been arrested and tried twice before on similar charges, but not convicted. In his teen-age years, he was arrested for fighting 4 times, and was sent to a juvenile detention home twice. Interviews with his neighbors has revealed that he has come home

intoxicated on many occasions, and loud crashing sounds and loud voices have been heard on some of those occasions. He is in good health, with no known physical impairments. He does, however, bear a few scars, and those scars appear to be relatively minor knife wounds.

WAIS Scores

Information	13	Picture Completion	13
Similarities	12	Picture Arrangement	16
Arithmetic	8	Block Design	16
Vocabulary	10	Object Assembly	10
Comprehension	7	Digit Symbol	10
Digit Span	10		

Digits Forward Raw Score 14   Digits Backward Raw Score 12

VIQ 100   PIQ 115   FSIQ 108

Observations

The examinee made disparaging remarks during Arithmetic, Object Assembly, and Comprehension, e.g., "childish", "not worth my time", "waste of time", "boring". He also made remarks about authority figures (people such as teachers, parents, and employers) "having it in for me". He challenged the authority of the examiner, with considerable verbal belligerence. His compliance with instructions was extremely reluctant, with reluctance verbalized, e.g., "Oh, all right", "If I have to", etc. He made rhymes with the Vocabulary words (clang associations), and was flippant. His visual-motor speed and dexterity were very good.He occasionally tried to "bargain" with the examiner to avoid doing the tasks on the WAIS, even when reminded that the results of the evaluation might affect his

future. His reality contact was good.   Finally, he expressed feelings of persecution when asked if he could do better or try harder.

Processing - Input

After DAVE would be loaded and started the user would put in the WAIS scores, as shown above.   The input menus would be presented next.   Each item on an input menu is selected by a letter.   The following menu selections would apply to the background information and observations given above, and would be selected by the user:

input menu # 2

I   Clang associations on Vocabulary

input menu # 3

B   Flippancy

input menu # 4

A   Good visual-motor coordination

input menu # 5

E   No serious hearing impairment

F   Supercilious attitude

H   Good visual-motor speed

I   A schemer

M   Reality contact good

input menu # 6

I   Lacks consideration for other people's feelings

and rights

J   History of violent behavior

L   Overt hostility toward the examiner

input menu # 7

A   Challenged examiner's authority, at least half-
         seriously
All of the input menus are listed in Appendix B.

That   would complete the data input.   The first   subsequent
action   would   be the calculation of the verbal   and   performance
mean scores,   and the verbal and mean scatters.   The verbal mean
would   be   the sum of all the verbal subtest scores,   except   for
Digit Span,   divided by 5.   For this case,   it would be 10.   The
Performance   mean would be calculated by dividing the sum of   all
of the Performance subtest raw scores by 5.   For   this   case,   it
would   be   13.   The scatters would be calculated by finding   the
difference between the high and low scores.   The Verbal   Scatter
and Performance Scatter would both be 6 for this case.

The data would now be in a usable form.   The next step would
be   to   examine the sign rules exhaustively,   to see   which   ones
would   apply to this case,   and if any should be held in reserve,
in   case they could add something after DAVE is "certain" of   its
basic   findings.   There would be a total of 17 rules   fired   for
this case,   and one of them would be held in reserve.   Space and
readability   prohibit   listing the full text of each   rule   here.
Again,   all   of   the   sign rules are given in   Appendix   A.   The
numbers of the fired rules would be 002, 005, 006, 009, 023, 026,
029,   030, 032, 034, 037, 058, 064, 081, 085, 096, and 106.   Rule
032   would   be   held   in   reserve,   because   of   its   "(certain
(psychosis))"   part.   The   Input   part of the program   would   be
complete,   and   processing   would begin in the functions   in   the
Inference Engine.

Processing - Inference Engine

To reduce the amount of computation, the system first attempts to find any clinical entities for which there is very strong evidence, in which case the entity is considered superqualified. It also looks for the opposite condition, where the evidence indicates that the entity should be rejected as a reasonable possibility, in which case the entity is considered disqualified. The list of rules for superqualification and disqualification, called "sd-qualifiers", for each clinical entity are given in Appendix C. That entire list is searched in a single pass to see if any of the clinical entities can be superqualified or disqualified. In this case, antisocial personality disorder is a superqualifier, by virtue of the user's selection of item "M" from input menu number 5 and items "I" and "J" from input menu number 6. There is also a disqualifier, mental retardation, because FSIQ is higher than 69. Mental retardation is therefore removed from the list of clinical entities to be considered in the processing which immediately follows.

The clinical entities which have not been disqualified, including any superqualifiers, are examined to see how much support the data provide for each entity. In this case, those would be antisocial personality disorder, giftedness, neurosis, psychosis, and organic brain syndrome. The fired sign rules are separated by the type of evidence in the first part of each rule, observations, WAIS scores, or background information. If a rule contains more than one type of information, it is assigned to each of the applicable categories. In this case, rules 058, 081,

and 096 would be put into the "observations" list. The rest of the rules, those being 002, 005, 006, 009, 023, 026, 029, 030, 032, 034, 037, 064, 081, 085, and 106, would all be put into the "WAIS scores" list. The non-disqualified clinical entities will then be examined, one by one, against the rules assigned to observations, WAIS scores, or background information. This examination will have three possible outcomes for each rule and clinical entity, "definitely supports [the notion that the clinical entity is present in the examinee], "does not support", and "might add".

If the clinical entity is specifically named in one of the rule's hypotheses, that rule is considered as "definitely supports" for the notion of the presence of the clinical entity in the examinee. "Definitely supports" is also ruled if one of the rule's hypotheses names an entity which is a subset of one of the clinical entities. The rule number and hypothesis number are put into a list. For example, many of the sign rules have "schizophrenia" as an hypothesis. Schizophrenia is a type of psychosis, and a rule which has a "schizophrenia" hypothesis would therefore support the notion that psychosis is present in the examinee.

In the case of "does not support", the rule number is noted and a note is made if the clinical entity under consideration is directly contradicted by any of the rule's hypotheses. "Does not support" is merely noted for each entity-rule combination. "Might add" is noted and held in reserve, in case the weighing of the evidence reveals the clinical entity as present in the examinee. The hypotheses in the "might add" category have

information in them which would be useful for investigation during further testing or in psychotherapy. When all rule numbers and hypothesis numbers, if applicable, have been put into separate lists according to the clinical entity against which they were considered, and the type of support or addition they might make is done, processing proceeds to the next cluster of functions.

Any superqualifier is taken first. If there is more than one superqualifier, the following process is repeated. All of the evidence which supports the conclusion of the presence of the superqualifier is put into a list for output, observations first, then scores and background information. The hypotheses from the "might-add" hypotheses are put into the list next. Those hypotheses are the ones that would add information which might be worth pursuing if the clinical entity proved to be present in the examinee. In the present case, the results of examining the rules based on test observations are presented in Table 1, on the next page.

Table 1

Results of Scan of Observations-Based Rules

for Antisocial Personality Disorder

Definitely Support		Do Not Support	Might Add Ideas for Therapy or Testing		
Rule #	Hyp #	Rule #	Rule #	Hyp #	Remarks
058	01				
081	01				
096	01				

This is extremely strong support, in fact, the strongest that a scan of the rules can give. There are three reasons that the support is so strong: observations are considered to be the most important type of data, all of the rules based upon them support the notion of antisocial personality disorder being present, and the hypothesis in each supporting rule is the very first one. The first hypothesis is the one considered the most likely to be true if a given piece of data is true for the examinee. The results of the processing for WAIS test scores rules for the antisocial personality disorder would be as shown in Table 2, one the next page.

Table 2

Results of Scan of WAIS Test Scores Rules

for Antisocial Personality Disorder

Definitely Support		Do Not Support	Might Add Ideas for Therapy or Testing		
Rule #	Hyp #	Rule #	Rule #	Hyp #	Remarks
002	01	005	009	01	Impaired judgement
006	06	026	029	01	Superior visual-motor coordination and perceptual organization
023	03	030	029	04	Contraindication of organicity
081	01	032	034	01	Impaired judgement and possible inflexibility
		037			
		064			
		085			
		106			

The support from the WAIS test scores is not as definite as this, but is stronger for antisocial personality disorder than for any other clinical entity. Note that the contents of the hypotheses from the rules which "Might Add Ideas for Therapy or Testing" strengthen the impressions from observations or make judgements about clinical entities which may be rejected as possibilities.

The above process is repeated for each non-discarded clinical entity. The rules containing observation evidence are considered first. The hypotheses in those rules are examined to see if any of them support the notion that the clinical entity being examined is present in the examinee. If a rule lends such support, the number of the lowest-numbered hypothesis supporting the notion of the entity's presence and the entity's name are put into a list. The resulting list would be a list of elements. Each element would contain the rule number, the supported clinical entity, and the lowest-numbered supporting hypothesis in that rule. In the example case, such a list would be empty, since none of the observations support any of the clinical entities other than the superqualifier. The same process would then be done for WAIS score patterns and background information, with a separate list of lists for each of those. For the example case, the portion of the list for the WAIS score support for neurosis is shown below:

(scores-support

.

.

((002) (neurosis) (06))

((030) (neurosis) (04))

.

.

((<last rule number>) (<last clinical entity>)

(<last hypothesis number>)   )

The "(scores-support" is the beginning and identification of the list, and the very last right parenthesis closes the list. The

dots were put in to indicate that there might be list elements before and after the items which lend support to neurosis. There would be two other such lists, one for observations and one for background information.

An examination of the above lists of lists would then be done. For each rule number, any hypotheses lending support to a clinical entity would be examined. Since a rule may have a number of hypotheses, and might therefore support more than one clinical entity, the entity with the lowest hypothesis number would be considered the entity supported by that rule. A count for each clinical entity would be kept for each type of evidence. The count for each clinical entity. would be incremented by one for each rule supporting the presence of that entity. The clinical entity with the largest number of supporting rules would be considered to be the entity most strongly supported by a given category of evidence. At this point, then, the entity most strongly supported by observations, the one most strongly supported by WAIS score patterns, and the entity most strongly supported by background information are known. In the case given, the support from observations alone was for the superqualifier, antisocial personality disorder. Test-score rules most strongly supported the presence of psychosis. The number of WAIS score rules most strongly supporting the various clinical entities are given at the top of the next page, by the entity and the number of rules supporting each entity:

Antisocial personality disorder   2

Neurosis   0

Psychosis   7 .

Organic brain syndrome   2

Psychosis had seven of the lowest-numbered hypotheses from the test-score rules, and was therefore the most strongly-favored clinical entity, on the basis of the WAIS score rules alone. There were no rules based on background information which were fired.

The final conclusions would be drawn at this point. If there are any superqualifiers, they are automatically put into the output list, and are noted as superqualifiers. If they were the clinical entity most strongly supported by observations, WAIS scores, or background information, that fact would be put into the output list. Any clinical entity which was not a superqualifier and was most strongly supported by at least the observations rules would be put into the output list next. If there was a clinical entity supported by the WAIS scores, it would be reported after that. If that other clinical entity was also the most strongly supported by WAIS score pattern rules or background information or both, that would also be reported. In the example case, psychosis would be reported as a possibility, but supported only by the scores. That would alert the user to the notion that the antisocial personality disorder would be considered the primary disorder, with psychosis being a more remote possibility.

In the cases where there was no superqualifier, the entity most strongly supported by observation rules would be given

priority for insertion into the output list. If it was also the second most-strongly-supported entity in the WAIS test score pattern rules, it would be taken as the most likely clinical entity to be present in the examinee at the time of testing.

Processing - Output

The output portion of the system is relatively trivial. All of the lists for output have already been determined, and the output section would present them to the user on the terminal screen.

Results

At the time of this report, the design had been completed for DAVE. The input menus, which contain possible observations and background information, were started, and some 146 rules had been created. More sign rules were needed, particularly in the background information area. Sign rules were also needed for giftedness. The system could also have benefited from finding some criteria for discarding giftedness from consideration, those criteria being desirable additions to the superqualifier and disqualifier list. However, complete coding, testing, and debugging had not been done. The results can only be known after DAVE has been at least coded and tested. A report of the results would be appropriate at that time, since full debugging may take quite some time after the system is up and running.

System Limits

Every computer software system has capability and performance limits, and DAVE is no exception. DAVE is an "intelligent" system, but that intelligence is limited, as it is for all present expert systems. This chapter describes those limits.

Lack of Knowledge Depth in the Clinical Psychology Domain

DAVE does not have all of the deep knowledge of psychology possessed by a human expert. A human clinical psychologist is the result of many years of life itself, plus specialized intensive training and experience, who can incorporate life's experiences into a personal knowledge base. Part of that personal knowledge base is useful in the psychologist's professional life. By contrast, DAVE has no life outside its very limited task, and has no ability to incorporate any such knowledge which might be useful in the performance of its very limited task.

To some extent, this weakness is a weakness of all expert systems. At present, there is no way to avoid it. The compensation for that weakness is the obvious one of careful and sensible use of these systems for their intended purposes only.

Lack of New Domain Knowledge Generation Capability

A human clinical psychologist can not only use what is already known, but can also do research and create new knowledge. Ideas for research may come from the logical and rational part of the mind, but may also come from the holistic part of the mind. The logical part is the one that allows a human being to perceive logical extensions of what is already known, is the part that our

schools train, is fairly well understood, and is comparitively easy to transfer to a computer. It is, by and large, also the part that makes the smaller advances within established scientific paradigms. It is the one with which we are more comfortable, for most of us can call upon it at will. The holistic part of the mind is entirely different. It is the part of the mind that makes the daring leaps into the unknown, the one that creates new scientific paradigms. We do not understand it, our schools do not train it, and most of us cannot call upon it at will. It seems to communicate its ideas sporadically and without notice. Many of the ideas it originates prove to be incorrect, but the ideas which are correct are frequently called such things as "leaps of genius". DAVE cannot even come close to emulating that kind of mental activity. It cannot generate new WAIS test-score patterns or observation or background-information data and relate that data to clinical entities. One could say that DAVE learns only by being explicitly taught; it does not form new data-conclusions relationships on its own.

Lack of Compensation for Errorful Data or Knowledge

DAVE depends upon the judgement of the human clinician for the validity of the data and knowledge furnished to it. It cannot detect clerical errors in WAIS scores input or selections of applicable background-information and observation items from the input menus. It does, however, provide feedback at intervals after input, to allow the user to check for such errors. The same idea also applies to new additions to its knowledge base.

Lack of Ability to Judge Data Validity

DAVE cannot judge whether test scores are valid measures of ability or potential. This weakness differs from the weakness described just above in that the potential error occurs in the score itself, rather than in the clerical transfer of the score from the outside world into the system. Many of the examinees for which DAVE will be used will be mentally impaired, some of them quite seriously. The human user will have to judge whether the obtained scores reflect the examinee's ability or potential.

Human judgement also plays an important role in deciding whether input menu items will be selected or not. For example, item "I" on input menu number 3 reads "frequently gave irrelevant details". The user will have to decide what constitutes the "frequent" occurence of that behavior when deciding whether to select that menu item. The same applies for many of the other menu items.

Inability to Compensate for Extremely High or Low Scores

The WAIS subtest scores have numerical limits. The lowest possible score on each subtest is 1, the highest score is 19, and an average score is 10. Even these generous limits impose problems. A person whose subtest scores are all in the range of 18 or 19, would have an FSIQ of about 145. That is the upper limit of the WAIS's measurement ability. The lower limit of the WAIS, which would be approached for someone whose subtest scores are all 1 or 2, would be an IQ of about 45.

For DAVE's functioning, the above limits can lead to some very false impressions when one Verbal or Performance score is very close to the average range and the other Verbal or

Performance scores are extremely high or low. For example, a gifted person might very well have scores for the Verbal subtests of Information, Similarities, Arithmetic, Vocabulary, and Comprehension in the range of 17 or higher. If the Digit Span score for that person is "only" about 13 or lower, then the Digit Span subtest would be perceived as a "weakness". In fact, a Digit Span subtest score of 13 is still very good, in fact above about 83% of the American human adult population. The present design of DAVE cannot compensate for such a false "low" score. The opposite of the preceding example also applies. Someone who is mentally retarded might score in the range of 3 or lower in Information, Similarities, Arithmetic, Vocabulary, and Comprehension, but 7 or higher in Digit Span. Digit Span would be considered to reflect a personal strength of some sort for that person, but would still be a low score when compared to the general population. To be more exact, a subtest score of 7 is higher than only 17% of the expected performance of the American human adult population. DAVE'S present design does not compensate for such a false "high". It will probably be possible to revise the design to eliminate these types of potential errors.

<u>Lack of Sufficient Knowledge in the Present Knowledge Base</u>

The weaknesses described above were of a rather theoretical nature. There were also some specific shortcomings in DAVE's knowledge at the time of this report. Some criteria for discarding giftedness as a possible quality of the examinee would be a helpful addition, since that would reduce processing time. More sign rules are needed for giftedness, as well, for cases

where the IQ may not reflect the ability of the examinee. Such cases would arise, for example, where the examinee was grossly deprived of early intellectual stimulation, or had substandard educational opportunities. More sign rules are also needed for background information, even if it is the weakest of the three basic types of information.

Summary

DAVE does have weaknesses, and some of them might lead to occasional false conclusions. One of them, the lack of deep knowledge of the entire clinical psychology domain, is a typical weakness in all expert systems. It cannot generate new domain knowledge, but must be explicitly taught. It depends on the care and judgement of the human clinical to avoid the input of data which is clerically incorrect or invalid.

It may be possible to revise DAVE's design to eliminate its inability to compensate for extrememly high or low scores.

The needed additions to the knowledge base could be obtained relatively quickly, or they could be delayed until most of the coding is completed.

Conclusions

The identification of the syndromes suffered by the mentally ill is a difficult problem, but the automation of a significant and routine part of the task can be done with AI techniques. The structured clinical psychological knowledge found in Gilbert (1978) and Ogdon (1977) has resulted in 146 rules. In addition, the insights provided by a very able human expert resulted in other rules which could simplify and speed up the task of examining the evidence. All of those rules relate clinical information from WAIS scores, the observations during its administration, and any background information which might be available to the clinical entities of antisocial personality disorder, giftedness, mental retardation, neurosis, organic brain syndrome, and psychosis. The rules also contain more minor aspects of mental illness, such as anxiety and depression. Those rules' existence shows the potential of AI methods for creating a system to help clinical psychologists do their work.

DAVE will not be able to outperform a human clinician when given the same evidence to work with, because it is only as good as the knowledge and methods provided to it. It has been designed to learn more from its users, with provisions for additions to and deletions from the various parts of its knowledge base.

More remains to be done, much more. The initial coding and testing have yet to occur, and they may well reveal the need for many changes. Once the system has achieved an acceptable level of competence, perhaps it can be released to the field.

In a sense, DAVE will never be done, especially if it is

released to the field. The issues in clinical psychology are not settled, and many differences of opinion exist, in both theory and practice. If DAVE is released to the field, it might be possible for the individual user to customize it.

For the near future, the coding, testing, and debugging are the obvious task. Suitable competence criteria will have to be selected, in order to define the point at which "debugging" ends and "customization" begins.

For the further future, it might be possible to make DAVE only one part of a complete expert system to assist clinical psychologists. The main barrier to that more ambitious goal is the lack of natural language processing sophistication. Our present systems struggle to understand normal speech in everyday contexts. They would be utterly stymied by the likely reaction of a psychotic to the Rorschach Inkblot Test. There are certain aspects of the WAIS that the natural langauge systems cannot handle, as well. The examinee's responses to some of the verbal subtests can suggest further avenues for clinical exploration in later testing or interviews. Our present natural language systems are inadequate for that, at least at present.

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Glossary

Antisocial Personality Disorder

People with this mental disorder are frequently called either "psychopaths" or "sociopaths". The primary behavioral pattern is characterized by living for immediate gain or pleasure, often at the expense of others. This pattern is not the result of cognitive deficiency.

Clinical Entity

As used in this Report, the set of clinical phenomena which DAVE will be able to deal with, those being the antisocial personality disorder, giftedness, mental retardation, neurosis, psychosis, and organic brain syndrome.

Clinical Psychologist

The exact definition of the training and other qualifications vary widely from state to state. Usually, someone with a Ph.D. in clinical psychology or a closely-related field who is certified, licensed, or otherwise entitled by a state to practice clinical psychology. A clinical psychologist's training is entirely in psychology, unlike a psychiatrist's training. The psychiatrist is an M.D.; the clinical psychologist is not.

Cognitive

In this report, the type of mental activity that most people regard as "thinking", i.e., logical, rational, problem-solving mental activity.

Giftedness

Cognitive giftedness is a matter of degree and open to opinion, but is used in this report to mean the highest-scoring 2% of the general population on an intelligence test, such as the WAIS.

Mental Retardation

This term is defined to mean the lowest-scoring 2% of the general population on an intelligence test, with a corresponding low level of ability to function in everyday life.

Neurosis

A mental disorder with the primary symptom pattern of anxiety or depression, sometimes both, when neither would appear to be justified. Contact with the reality of everyday living is otherwise reasonably intact.

Organic Brain Syndrome

A mental disorder caused by physical damage to the brain itself. The resulting behavioral pattern depends on the location and severity of the damage.

Psychosis

A mental disorder characterized by a loss of contact with the reality of everyday living.

Rorschach Inkblot Test

A widely-used test in clinical psychology, designed to obtain information about the examinee's emotional life. The test materials consist of cards which have figures similar to those made by putting a few drops of ink into the crease of folded paper, then closing the two halves of the paper to create a symmetrical pattern. The examinee is requested to describe what the figures on the cards look like or could be. The Rorschach requires the examinee to use fantasy more actively than the Thematic Apperception Test, which see below.

Thematic Apperception Test

A widely-used test in clinical psychology, disigned to obtain

information about the examinee's emotional life. The test materials consist of pictures, which are handed to the examinee one at a time. The examinee is requested to tell a story about the situation shown in each picture. The clinician is given a great deal of latitude in the selection of pictures which are given to a particular examinee. As few as 5 or as many as 20 pictures may be used for an examinee.

Visual-motor

All of the abilities and activities associated with the complete process of seeing something, understanding it, and making some sort of an active bodily reaction to it. The active bodily reaction might be pressing a button, reaching for and grasping a baby's rattle, or running to a location where a tennis ball will be and hitting it.

Visual-perceptual

All of the abilities and activities associated with seeing something and understanding it. The understanding may or may not reflect objective reality.

Appendix A

Note: In some of the rules, there are references to menu

selections, and those are in the form "(# L)", where "#" is a

menu number and "L" is a letter which is the selector of an item

from the menu specified by "#". The menus themselves are in

Appendix B.

```
;These are the sign rules in the abbreviated form, with all data
;types within each rule that would be empty, i.e., have the word
;none    in them, cut out.  A further change was made in these
;rules.  Redundant rules were eliminated and the score portion of
;the signs was cast into LISP-ese.  Also, the text expression of
;the  observations and background or social history were  changed
;to  make direct reference to the input menu items.  Those  last
;three changes reflect the latest thinking, i.e., as of 5-3-84.
(asetq sign-rules '(
(rule001
  (score (greaterp viq (plus piq 9)))
  (hypothesis01
    (main (qualifier probably) (most neuroses))
    (secondary (qualifier especially)
               (anxiety and tension states) (neurasthenia)
               (obsessive-compulsive conditions))
    (additional none))
  (hypothesis02
    (main (qualifier probably) (most psychoses))
    (secondary (qualifier particularly) (schizophrenia))
    (additional none))
  (hypothesis03
    (main (qualifier none) (organic and aphasic conditions))
    (secondary (qualifier particularly)
               (right hemisphere dysfunctioning))
    (additional none))
  (hypothesis04
    (main (qualifier none) (depressive conditions))
    (secondary none)
    (additional none))
  (hypothesis05
    (main (qualifier none) (older normal individuals))
    (secondary none)
    (additional none))
  (hypothesis06
    (main (qualifier none)
                        (patients tending to remain in therapy))
    (secondary none)
    (additional none))
  (hypothesis07
    (main (qualifier none) (or (good academic achievement)
                               (overachieving)))
    (secondary none)
    (additional none))
  (hypothesis08
```

```
        (main (qualifier none) (psychotic depressive trend))
        (secondary none)
        (additional none))
    )
    (rule002
      (score (lessp viq (difference piq 9)))
      (hypothesis01
        (main (qualifier none) (or (antisocial personality disorder)
                                   (narcissistic character disorder)))
        (secondary none)
        (additional none))
      (hypothesis02
        (main (qualifier none)
                             (adolescent delinquents and sociopaths))
        (secondary (qualifier although may not hold for)
                   (delinquents with good reading ability))
        (additional none))
      (hypothesis03
        (main (qualifier organic setting)
                  ((left hemisphere brain damage)
                                        (diffuse brain damage)))
        (secondary none)
        (additional none))
      (hypothesis04
        (main (qualifier mental retardation setting)
                 (negate (acting out tendencies)))
        (secondary (qualifier especially) (high grade familial type))
        (additional none))
      (hypothesis05
        (main (qualifier likely) (and (poor academic achievement)
                                      (poor reading ability)
                                      (doers not thinkers))))
        (secondary none)
        (additional none))
      (hypothesis06
        (main (qualifier possible) (neurotic condition))
        (secondary (qualifer (such as)) (or (hysteria)
                                        (cyclothymic character disorder)))
        (additional none))
    )
    (rule003
      (score (and (greaterp piq 89) (lessp piq 111) (lessp viq 81)))
      (hypothesis01
        (main (qualifier none) (learning disabilities))
        (secondary none)
        (additional none))
      (hypothesis02
        (main (qualifier none) (delinquency))
        (secondary none)
        (additional none))
    )
    (rule004
      (score (lessp i (difference vmean 2)))
      (hypothesis01
        (main (qualifier none) (impoverished early environment))
        (secondary (qualifier including) (lack of formal schooling))
        (additional none))
```

```
    (hypothesis02
      (main (qualifier none) (repressive defenses))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier none) (withdrawal tendencies))
      (secondary none)
      (additional none))
    (hypothesis04
      (main (qualifier none) (low scholastic aptitude))
      (secondary none)
      (additional none))
    (hypothesis05
      (main (qualifier possible) (or (anxiety) (hysteria)))
      (secondary none)
      (additional none))
    (hypothesis06
      (main (qualifier possible) (or (delinquent)
                                          (acting out tendencies)))
      (secondary none)
      (additional none))
    (hypothesis07
      (main ((qualifier psychotic setting) (possible))
                                    (or (schizophrenia)
                                        (brain damage)))
      (secondary ((qualifier organic setting) (specifically))
                              (left hemisphere damage))
      (additional none))
    (hypothesis08
      (main (qualifier possible) (organicity))
      (secondary none)
      (additional none))
  )
(rule005
  (score (greaterp i (plus vmean 2)))
  (hypothesis01
    (main (qualifier none) (intellectualizing tendencies))
    (secondary (qualifier possibly) (or (compensatory reactions)
                                    (early intellectual hothousing)))
    (additional none))
  (hypothesis02
    (main (qualifier neurotic setting)
                    (obsessive compulsive tendencies))
    (secondary none)
    (additional none))
  (hypothesis03
    (main (qualifier possible) (or (schizophrenic)
                                    (preschizophrenic)))
    (secondary (qualifier frequently) (paranoid tendencies))
    (additional none))
  )
(rule006
  (score (lessp cm (difference vmean 2)))
  (hypothesis01
    (main (qualifier none) (less than adequate judgement))
    (secondary (qualifier often) (in doubt-laden persons))
    (additional none))
```

```
    (hypothesis02
      (main (qualifier increased probability)
            (impulsive maladjusting emotionally unstable behavior))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier none) (obsessive-compulsive tendencies))
      (secondary none)
      (additional none))
    (hypothesis04
      (main (qualifier none) (schizophrenia))
      (secondary (qualifier except) (paranoid type))
      (additional none))
    (hypothesis05
      (main (qualifier (if cm < ds - 2) (may))
            (differentiate schizophrenics from organics))
      (secondary none)
      (additional none))
    (hypothesis06
      (main (qualifier none) (or (delinquent tendencies)
                      (antisocial personality disorder tendencies)))
      (secondary none)
      (additional none))
    (hypothesis07
      (main (qualifier none) (depressive conditions))
      (secondary none)
      (additional none))
    (hypothesis08
      (main (qualifier possible) (or (cerebellar damage)
                                     (left hemisphere damage)))
      (secondary none)
      (additional none))
)
(rule007
  (score (greaterp cm (plus vmean 2)))
  (hypothesis01
    (main (qualifier none) (adequate to better than average
                                (or (judgement) (common sense)
                                    (social competence)))))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier none)
                ((adequate to better than average ability)
                    (and (to delay impulsive reaction tendencies)
                         (to behave properly))
                    (in affect-arousing situations)))
    (secondary none)
    (additional none))
  (hypothesis03
    (main ((qualifier psychotic setting) (possible))
                (or (paranoid schizophrenic)
                    (psychopathic conditions))))
    (secondary none)
    (additional none))
)
(rule008
```

```
    (score (lessp i (difference cm 2)))
    (hypothesis01
      (main (qualifier posssible)
                      (hysterical condition referable to depression))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier possible)
                (chronic involutional paranoid psychosis))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier none) (hysteric))
      (secondary none)
      (additional none))
    (hypothesis04
      (main (qualifier none) (repression in hysteriod state))
      (secondary none)
      (additional none))
  )
  (rule009
    (score (greaterp i (plus cm 2)))
    (hypothesis01
      (main (qualifier none) (impaired judgement))
      (secondary (qualifier perhaps)
                      (in a neurosis with obsessional features))
      (additional none))
    (hypothesis02
      (main (qualifier possible) (psychosis))
      (secondary (qualifier none) (or (schizophrenic) (depressive)))
      (additional none))
  )
  (rule010
    (score (lessp ds (difference vmean 2)))
    (hypothesis01
      (main (qualifier likelihood of)
                (or ((or (clinically significant anxiety)
                        (clinically significant tension))
                    (and (clinically significant anxiety)
                        (clinically significant tension)))))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (distractibility))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier possible) (organic condition))
      (secondary none)
      (additional (and (ds < cm - 2) (ds < v - 2)))
        (enhance main))
    (hypothesis04
      (main (qualifier perhaps)
              (organic condition in left hemisphere))
      (secondary none)
      (additional  (and (ds < cm - 2) (ds < v - 2)))
        (enhance main))
```

```
      (hypothesis05
        (main (qualifier possible) (manic-depressive conditions))
        (secondary none)
        (additional none))
  .   (hypothesis06
        (main (qualifier possible) (epileptic conditions))
        (secondary none)
        (additional none))
      (hypothesis07
        (main (qualifier possible)
                          (psychosomatic migraine conditions))
        (secondary none)
        (additional none))
      (hypothesis08
        (main (qualifier none) (hysteria))
        (secondary none)
        (additional none))
  )
  (rule011
    (score (greaterp ds (plus vmean 2)))
    (hypothesis01
      (main (qualifier none)
                (or (unusually good attentive processes)
                    (low distractibility) (low anxiety)
                    (easy and effortless contact with environment)))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier possible) (or (flattened afftect)
                                     (bland emotional life)))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier possible) (schizophrenia))
      (secondary (qualifier perhaps) (simple type))
      (additional (ds > v + 2))
        (enhance (main secondary)))
    (hypothesis04
      (main (qualifier possible) (psychopathic tendencies))
      (secondary none)
      (additional none))
    (hypothesis05
      (main (qualifier possible) (obsessive-compulsive tendencies))
      (secondary none)
      (additional none))
    (hypothesis06
      (main (qualifier none) (simple schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule012
    (score (greaterp df (plus db 2)))
    (hypothesis01
      (main (qualifier possible) (brain damage))
      (secondary none)
      (additional none))
    (hypothesis02
```

```
    (main (qualifier possible) (and (excessive rigidity)
                                    (concrete thinking)))
    (secondary (qualifier in the extreme)
               (thinking that has fragmented under pressure))
    (additional none))
  (hypothesis03
    (main (qualifier none)
          (better memory span than memory for symbol patterns))
    (secondary none)
    (additional none))
  (hypothesis04
    (main (qualifier in the extreme case) (psychosis))
    (secondary (or (depressive psychosis)
                   (schizophrenic psychosis)))
    (additional none))
  (hypothesis05
    (main (qualifier possible) (schizophrenia))
    (secondary (qualifier especially) (paranoid schizophrenia))
    (additional none))
)
(rule013
  (score (or (equal df db) (lessp df db)))
  (hypothesis01
    (main (qualifier none) (or (schizoid adult)
                               (schizophrenic adult)))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier possible) (or (blandness) (negativism)))
    (secondary none)
    (additional none))
)
(rule014
  (score (lessp a (difference vmean 2)))
  (hypothesis01
    (main (qualifier none)
          (and (poor ability'to concentrate)
                              (high distractibility)))
    (secondary none)
    (additional none))
  (hypothesis02   (main (qualifier none)
          (or (poor arithmetic reasoning)
              (lack of training in simple arithmetic skills)))
    (secondary none)
    (additional none))
  (hypothesis03
    (main (qualifier none) (anxiety))
    (secondary none)
    (additional none))
  (hypothesis04
    (main (qualifier none) (low scholastic aptitude))
    (secondary (qualifier perhaps)
               (reflecting rebellion against authority))
    (additional (i < vmean - 2))
      (enhance (main secondary)))
  (hypothesis05
    (main (qualifier possible)
```

```
                        (or (adolescent delinquency)
                                          (adolescent sociopathy))))
        (secondary none)
        (additional none))
    (hypothesis06
      (main (qualifier possible) (psychotic conditions))
      (secondary (qualifier perhaps) (schizophrenia))
      (additional (or (cm < vmean - 2) (pa < pmean - 2)))
            (enhance (main secondary)))
    (hypothesis07
      (main (qualifier possible) (organicity))
      (secondary (qualifier perhaps) (left parietal area))
      (additional none))
    (hypothesis08
      (main (qualifier possible) (alcoholism))
      (secondary none)
      (additional none))
    (hypothesis09
      (main (qualifier possible)
                (and (hysteria) (narcissistic conditions)))
      (secondary none)
      (additional none))
    (hypothesis10
      (main (qualifier possible) (suicide potential))
      (secondary none)
      (additional none))
)
(rule015
  (score (greaterp a (plus vmean 2)))
  (hypothesis01
      (main (qualifier likelihood of) (normal adjusting))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none)
                (or (low distractibility) (good concentration)))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier possible) (intellectualizing tendencies))
      (secondary (qualfier as in) (obsessive conditions))
      (additional none))
    (hypothesis04
      (main (qualifier possible) (paranoid overalertness))
      (secondary none)
      (additional none))
)
(rule016
  (score (greaterp a (plus ds 2)))
  (hypothesis01
      (main (qualifier none) (anxiety))
      (secondary (qualifier of the kind found in)
                (or (neurosis) (depression) (preschizophrenia)))
      (additional none))
)
(rule017
  (score (lessp a (difference ds 2)))
```

```
(hypothesis01
  (main (qualifier none) (or (relief from anxiety)
                             (freedom from distractibility)))
  (secondary (qualifier may be achieved through)
             (or (fantasy) (withdrawal)))

  (additional none))
(hypothesis02
  (main (qualifier possible) (anxious unreflective hysteric))
  (secondary none)
  (additional none))
(hypothesis03
  (main (qualifier possible) (brain damaged conditions))
  (secondary none)
  (additional none))
)
(rule018
 (score (lessp s (difference vmean 2)))
 (hypothesis01
  (main (qualifier none)
        (or (inability to think abstractly)
            (impaired ability to think abstractly)))
  (secondary none)
  (additional none))
 (hypothesis02
  (main (qualifier possible) (schizophrenic conditions))
  (secondary none)
  (additional none))
 (hypothesis03
  (main (qualifier possible) (or (organicity)
                                 (epileptic condition)))
  (secondary (qualifier perhaps) (left temporal lobe))
  (additional none))
 (hypothesis04
  (main (qualifier none) (antisocial personality disorder))
  (secondary none)
  (additional (and (piq >viq + 9) (pa > pmean + 2)))
     (enhance (main)))
 (hypothesis05
  (main (qualifier possible) (depressive conditions))
  (secondary none)
  (additional none))
 (hypothesis06
  (main (qualifier mental retardation setting)
                                  (endogenous type))
  (secondary none)
  (additional none))
 (hypothesis07
  (main (qualifier possible)
             (beat homeless downtrodden condition))
  (secondary none)
  (additional none))
 (hypothesis08
  (main (qualifier none) (cultural deprivation))
  (secondary none)
  (additional none))
 (hypothesis09
```

```
        (main (qualifier none) (chronic schizophrenia))
        (secondary (qualifier especially)
                    (chronic paranoid schizophrenia))
        (additional none))
)
(rule019
  (score (greaterp s (plus vmean 2)))

  (hypothesis01
    (main (qualifier none) (intellectualizing defenses))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier favorable indications)
                (and (for prognosis)
     (for continuing in therapy as opposed to early termination))))
    (secondary none)
    (additional none))
  (hypothesis03
    (main (qualifier possible) (obsessive-compulsive conditions))
    (secondary none)
    (additional none))
  (hypothesis04
    (main (qualifier has been associated with) (learning ability))
    (secondary none)
    (additional none))
  (hypothesis05
    (main (qualifier possible) (paranoid trends))
    (secondary none)
    (additional (and (a > vmean + 2) (pc > pmean + 2)))
        (enhance (main)))
  (hypothesis06
    (main (qualifier possible) (antisocial personality disorder))
    (secondary none)
    (additional none))
  (hypothesis07
    (main (qualifier possible)
                (or schizophrenic conditions)
                    (preschizophrenic conditions))
    (secondary none)
    (additional (pc < pmean - 2))
        (enhance (main)))
  (hypothesis08
    (main (qualifier none) (paranoid tendencies))
    (secondary none)
    (additional none))
  (hypothesis09
    (main (qualifier none) (acute paranoid schizophrenia))
    (secondary none)
    (additional none))
)
(rule020
  (score (lessp v (difference vmean 2)))
  (hypothesis01
    (main (qualifier none)
            (lasting effect of impoverished early environment))
    (secondary none)
```

```
      (additional none))
  (hypothesis02
    (main (qualifier neurotic setting)
            (or (neurasthenic condtions) (hysterical conditions)))
    (secondary none)
    (additional none))
  (hypothesis03
    (main (qualifier psychotic setting)
            (schizophrenic conditions other than paranoid))
    (secondary none)
    (additional (ds > vmean + 2))
 (enhance (main)))
(hypothesis04
    (main (qualifier none) (endogenous mental deficiency))
    (secondary none)
    (additional none))
(hypothesis05
  (main (qualifier possible) (organic condition))
    (secondary (qualifier sometimes)
                (or (with local lesions in dominant hemisphere)
            (with local lesions in subordinate temporal lobe)))
    (additional none))
  (hypothesis06
    (main (qualifier possible)
            (or (cyclothymic personality)
                    (inadequate personality)))
    (secondary none)
    (additional none))
)
(rule021
  (score (greaterp v (plus vmean 2)))
  (hypothesis01
    (main (qualifier none)
      (or (intellectualizing tendencies)
          (obsessive-compulsive tendencies)))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier possible)
            (or (schizophrenic conditions)
                (over ideational preschizophrenic conditions)))
    (secondary none)
    (additional none))
)
(rule022
  (score (lessp pa (difference pmean 2)))
  (hypothesis01
    (main (qualifier likelihood of)
            (or (impaired ability in getting along with others)
                (relatively poor planning)
                (impulsivity in interpersonal relations)))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier none)
  (normals from poor cultural backgrounds lacking sophistication))
    (secondary none)
```

```
         (additional none))
    (hypothesis03
      (main (qualifier none)
             (and (depressive conditions)
                   (preoccupation with death))))
      (secondary none)
      (additional none))
    (hypothesis04
      (main (qualifier possible) (organicity))
      (secondary (qualifier particularly)
                  (or (right hemisphere dysfunctioning)
                       (diffuse dysfunctioning)))
      (additional (bd < pmean - 2))
         (enhance (main)))
   (hypothesis05
      (main (qualifier possible) (organicity))
      (secondary (qualifier perhaps)
              (right frontal lobes))
      (additional (bd < pmean - 2))
         (enhance (main)))
    (hypothesis06
      (main (qualifier none) (procrastinating tendencies))
      (secondary none)
      (additional none))
    (hypothesis07
      (main (qualifier (in a psychotic setting) (probable))
             (schizophrenic conditions))
      (secondary none)
      (additional none))
    (hypothesis08
      (main (qualifier possible) (obsessive-compulsive tendencies))
      (secondary none)
      (additional none))
    (hypothesis09
      (main (qualifier possible)
              (or (psychosomatic migraine condition)
                   (epileptic condition)))
      (secondary none)
      (additional none))
    (hypothesis10
      (main (qualifier none)
              (or (intellectualizing neurotic)
                   (intellectualizing paranoid))))
      (secondary none)
      (additional none))
)
(rule023
  (score (greaterp pa (plus pmean 2)))
  (hypothesis01
    (main (qualifier none) (and (socially adept) (punctual)))
    (secondary (qualifier perhaps) (normally adjusting))
    (additional none))
  (hypothesis02
    (main (qualifier none) (favorable prognosis with therapy))
    (secondary none)
    (additional none))
  (hypothesis03
```

```
        (main (qualifier piq > viq + 9)
                  (or
          (reinforced impression of antisocial personality disorder)
                  (reinforced impression of delinquency)))
        (secondary (qualifier suggests)
          (development and retention of  ability to scheme without
            regard for social consequences of the schemes))
        (additional none))
      (hypothesis04
        (main (qualifier possible) (paranoid tendencies))
        (secondary none)
        (additional none))
  )
  (rule024
    (score (lessp pc (difference pmean 2)))
    (hypothesis01
      (main (qualifier probably)
          (emotional disturbances interfere with ability to
              distinguish essential from nonessential details))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (and (poor basic perceptual ability)
                                  (poor conceptual ability)
                                  (poor visual concentration)))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier none) (anxiety))
      (secondary none)
      (additional none))
    (hypothesis04
      (main (qualifier possible) (schizophrenic conditions))
      (secondary none)
      (additional none))
    (hypothesis05
      (main (qualifier possible) (brain damage))
      (secondary (qualifier including) (alcoholism))
      (additional none))
    (hypothesis06
      (main (qualifier none) (psychotic depression))
      (secondary none)
      (additional none))
    (hypothesis07
      (main (qualifier none) (schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule025
    (score (greaterp pc (plus pmean 2)))
    (hypothesis01
      (main (qualifier none)
          (and
              (greater than average breadth of general information)
              (satisfactory adjusting)))
      (secondary none)
      (additional none))
```

```
(hypothesis02
  (main (qualifier none)
      (adequate ability to differentiate
          essential from nonessential details))
  (secondary none)
  (additional none))
(hypothesis03
  (main (qualifier (and (with educational handicaps)
                   (may be here rather than on a)))
          (good efficiency in concentration))
  (secondary none)
  (additional none))
(hypothesis04
  (main (qualifier possible)
          (or (antisocial personality disorder)
              (delinquent tendencies)))
  (secondary none)
  (additional none))                      .
(hypothesis05
  (main (qualifier mental retardation setting)
                                  (endogenous type))
  (secondary none)
  (additional none))
(hypothesis06
  (main (qualifier none) (favorable prognosis in therapy))
  (secondary none)
  (additional none))
(hypothesis07
  (main (qualifier with bd < pmean - 2)
          (adequate perception with poor visual-motor ability))
  (secondary none)
  (additional none))
(hypothesis08
  (main (qualifier none) (obsessive-compulsive tendencies))
  (secondary none)
  (additional none))
(hypothesis09
  (main (qualifier possible) (paranoid over-alertness))
  (secondary none)
  (additional none))
)
(rule026
  (score (lessp oa (difference pmean 2)))
  (hypothesis01
    (main (qualifier likelihood of) (or (anxiety) (tension)))
    (secondary (qualifier possibly associated with)
               (or (bodily concern) (castration anxiety)))
    (additional none))
  (hypothesis02
    (main (qualifier likelihood of) (depressive tendencies))
    (secondary (qualfier perhaps) (with aboulia))
    (additional none))
  (hypothesis03
    (main (qualifier possible) (brain damage))
    (secondary (qualifier particularly) (to right hemisphere))
    (additional none))
  (hypothesis04
```

```
          (main (qualifier possible) (schizophrenic conditions))
          (secondary (qualifier especially) (or (acute type)
                                              (anxious type)))
          (additional none))
       (hypothesis05
          (main (qualifier none) (hyperactive tendencies))
          (secondary none)
          (additional none))
       (hypothesis06
          (main (qualifier possible) (neurasthenia))
          (secondary none)
          (additional none))
)
(rule027
  (score (greaterp oa (plus pmean 2)))
  (hypothesis01
     (main (qualifier none) (good perceptual-motor coordination))
     (secondary none)
     (additional none))
  (hypothesis02
     (main (qualifier possibly) (good creative ability))
     (secondary none)
     (additional none))
  (hypothesis03
     (main (qualifier none) (favorable prognosis for therapy))
     (secondary none)
     (additional none))
  (hypothesis04
     (main (qualifier possible) (or (disciplinary problems)
                                    (delinquency)))
     (secondary none)
     (additional none))
  (hypothesis05
     (main (qualifier mental retardation setting)
                                          (endogenous type))
     (secondary none)
     (additional none))
  (hypothesis06
     (main (qualifier possible)
             (or (schizophrenic conditions)
                 (preschizophrenic conditions)))
     (secondary none)
     (additional none))
)
(rule028
  (score (lessp bd (difference pmean 2)))
  (hypothesis01
     (main (qualifier none)
             (or (right hemisphere organic condition)
                 (right parietal lobe organic condition)))
     (secondary none)
     (additional none))
  (hypothesis02
     (main (qualifier likelihood of) (anxiety))
     (secondary none)
     (additional none))
  (hypothesis03
```

```
        (main (qualifier likelihood of) (or (stress) (tension)))
        (secondary none)
        (additional none))
    (hypothesis04
        (main (qualifier none) (or (hyperactive tendencies)
                                   (impulsive tendencies)))
        (secondary none)
        (additional none))
    (hypothesis05
        (main (qualifier none) (and (tendency toward depression)
                                    (tendency toward aboulia)))
        (secondary none)
        (additional none))
    (hypothesis06
        (main (qualifier possible)
                (or excessive repression) (insecurity)
                                           (compulsivity))
        (secondary none)
        (additional none))
    (hypothesis07
        (main (qualifier possible)
                (or (delinquent tendencies)
                    (antisocial personality disorder tendencies)))
        (secondary none)
        (additional none))
    (hypothesis08
        (main (qualifier possible) (paranoid conditions))
        (secondary none)
        (additional none))
)
(rule029
    (score (greaterp bd (plus pmean 2)))
    (hypothesis01
        (main (qualifier none)
                (and (superior visual-motor coordination)
                     (superior perceptual organization)))
        (secondary none)
        (additional none))
    (hypothesis02
        (main (qualifier none) (favorable therapy prognosis))
        (secondary none)
        (additional none))
    (hypothesis03
        (main (qualifier possibly) (good creative ability))
        (secondary none)
        (additional none))
    (hypothesis04
        (main (qualifier none) (contraindication of organicity))
        (secondary none)
        (additional none))
    (hypothesis05
        (main ((qualifier psychotic setting) (possible))
                (or (schizophrenic conditions)
                    (preschizophrenic conditions)))
        (secondary none)
        (additional none))
    (hypothesis06
```

```
    (main (qualifier mental retardation setting)
                              (endogenous type))
    (secondary none)
    (additional none))
)
(rule030
 (score (lessp cd (difference pmean 2)))
 (hypothesis01
   (main (qualifier probability of) (brain damaged condition))
   (secondary (qualifier particularly)
                   (or (to right hemisphere) (to motor area)))
   (additional none))
 (hypothesis02
   (main (qualifier none) (and (tendencies toward depression)
                                (tendencies toward aboulia)))
   (secondary none)
   (additional none))
 (hypothesis03
   (main (qualifier probability of)
           (and (anxiety) (feelings of frustration) (tension)))
   (secondary none)
   (additional none))
 (hypothesis04
   (main (qualifier none) (or (neurotic personality)
                               (inadequate personality)))
   (secondary (qualifier possibly)
                   (or (with anxiety) (with hysteria)))
   (additional none))
 (hypothesis05
   (main (qualifier possible)
           (or dissociative processes) (schizoid processes))
   (secondary none)
   (additional none))
 (hypothesis06
   (main (qualifier possible)
           (or (hyperactive tendencies) (manic tendencies)))
   (secondary none)
   (additional none))
 (hypothesis07
   (main (qualifier possible)
           (beat homeless downtrodden conditions))
   (secondary none)
   (additional none))
 (hypothesis08
   (main (qualifier possible) (epileptic conditon))
   (secondary none)
   (additional none))
 (hypothesis09
   (main (qualifier none) (obsessive doubting))
   (secondary none)
   (additional none))
 (hypothesis10
   (main (qualifier none) (regressed schizophrenia))
   (secondary none)
   (additional none))
 (hypothesis11
   (main (qualifier possible) (psychotic depression))
```

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     (secondary none)
     (additional none))
 )
 (rule031
  (score (greaterp cd (plus pmean 2)))
  (hypothesis01
     (main (qualifier none)
              (and (relatively high psychomotor speed)
                   (relatively high visual-motor dexterity)))
     (secondary none)
     (additional none))
  (hypothesis02
     (main (qualifier possibility of)
              (or (relatively high rote learning ability)
                  (relatively high visual memory))
     (secondary none)
     (additional none))
  (hypothesis03
     (main (qualifier none)
                          (relative freedom from distractibility)))
     (secondary none)
     (additional none))
  (hypothesis04
     (main (qualifier none) (contraindicates low energy level))
     (secondary none)
     (additional none))
  (hypothesis05
     (main (qualifier possible) (schizophrenic blandness))
     (secondary none)
     (additional none))
 )
 (rule032
  (score (greaterp piq 110))
  (certain (psychotic))
  (hypothesis01
     (main (qualifier possibly) (antisocial personality disorder))
     (secondary none)
     (additional none))
 )
 (rule033
  (score (greaterp cm (plus vmean 2)))
  (hypothesis01
     (main (qualifier none) (strict moral code))
     (secondary none)
     (additional none))
 )
 (rule034
  (score (lessp cm (difference vmean 2)))
  (hypothesis01
     (main (qualifier may reflect) (inflexibility as well as
                                    impaired judgement))
     (secondary none)
     (additional none))
 )
 (rule035
  (score (lessp ds (difference v 2)))
  (hypothesis01
```

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        (main (qualifier none) (anxiety))
        (secondary none)
        (additional none))
  )
  (rule036
    (score (lessp ds (difference v 7)))
    (hypothesis01
      (main (qualifier possible) (incipient psychotic break))
      (secondary none)
      (additional none))
  )
  (rule037
    (score (and (or (equal ds a) (greaterp ds a)) (or (equal ds v)
                                               (greaterp ds v))))
    (hypothesis01
      (main (qualifier possible)
              (or (schizoid) (schizophrenic tendency)))
      (secondary none)
      (additional none))
  )
  (rule038
    (score (lessp ds (difference i 5)))
    (hypothesis01
      (main (qualifier none) (anxiety))
      (secondary none)
      (additional none))
  )
  (rule039
    (score (greaterp ds (plus a 2)))
    (hypothesis01
      (main (qualifier none) (antisocial personality disorder))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (low anxiety tolerance))
      (secondary none)
      (additional none))
  )
  (rule040
    (score (lessp ds (difference vmean 6)))
    (hypothesis01
      (main (qualifier none)
                              (anxious undifferentiated schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule041
    (score (lessp i (difference v 2)))
    (hypothesis01
      (main (qualifier none) (depression))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (hysteria))
      (secondary none)
      (additional none))
    (hypothesis03
```

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      (main (qualifier none) (schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule042
    (score (and (lessp i (difference cm 2))
                (lessp i (difference v 2))))
    (hypothesis01
      (main (qualifier none) (repressive tendency))
      (secondary none)
      (additional none))
  )
  (rule043
    (score (and (lessp i (difference s 2))
                (lessp a (difference s 2))
                (greaterp s (plus v 2))
                (greaterp s (plus ds 2)) ) )
    (hypothesis01
      (main (qualifier none) (paranoid trend))
      (secondary none)
      (additional none))
  )
  (rule044
    (score (lessp s (difference v 2)))
    (hypothesis01
      (main (qualifier none) (depression))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (organicity))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier none) (schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule045
    (score (greaterp s 18))
    (hypothesis01
      (main (qualifier none) (intellectualization))
      (secondary none)
      (additional none))
  )
  (rule046
    (score (and (greaterp s (plus vmean 2))
                (greaterp s (plus v 2))))
    (hypothesis01
      (main (qualifier none) (paranoid tendency))
      (secondary none)
      (additional none))
  )
  (rule047
    (score (and (greaterp viq 109) (lessp piq 90)))
    (hypothesis01
      (main (qualifier possible) (depressive trend))
      (secondary none)
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        (additional none))
  )
  (rule048
   (score (greaterp viq (plus piq 5)))
   (hypothesis01
     (main (qualifier none) (depressive neurosis))
     (secondary none)
     (additional none))
  )
  (rule049
   (observe (2 A))
   (hypothesis01
     (main (qualifier none) (depression))
     (secondary (qualifier none)
                  (or neurotic depression) (psychotic depression)))
     (additional none))
   (hypothesis02
     (main (qualifier none) (schizophrenia))
     (secondary (qualifier none)
                     (or (paranoid schizophrenia)
                         (simple schizophrenia)
                         (undifferentiated schizophrenia)))
     (additional none))
  )
  (rule050
   (observe (2 B))
   (hypothesis01
     (main (qualifier none) (psychotic depression))
     (secondary none)
     (additional none))
   (hypothesis02
     (main (qualifier none) (undifferentiated schizophrenia))
     (secondary none)
     (additional none))
  )
  (rule051
   (observe (2 C))
   (hypothesis01
     (main (qualifier none) (depression))
     (secondary none)
     (additional none))
   (hypothesis02
     (main (qualifier none) (hysteric))
     (secondary none)
     (additional none))
   (hypothesis03
     (main (qualifier none) (schizophrenic))
     (secondary none)
     (additional none))
  )
  (rule052
   (observe (2 D))
   (hypothesis01
     (main (qualifier none)
                     (chronic undifferentiated schizophrenia))
     (secondary none)
     (additional none))
```

```
)
(rule053
 (observe (2 E))
 (hypothesis01
   (main (qualifier none) (self-deprecating attitude))
   (secondary none)
   (additional none))
)
(rule054
 (observe (or (2 F) (5 D)) )
 (hypothesis01
   (main (qualifier none) (psychotic depression))
   (secondary (qualifier none) (schizophrenia))
   (additional none))
)
(rule055
 (score (and (or (equal i cm) (lessp i cm)) (or (equal s cm)
                                                (lessp s cm))
             (or (equal a cm) (lessp a cm)) (or (equal cm ds)
                                                (greaterp cm ds)))))
 (hypothesis01
   (main (qualifier none) (paranoid schizophrenia))
   (secondary none)
   (additional none))
)
(rule056
 (test-retst (or (equal (ds prev-ds) (greaterp ds prev-ds))))
 (hypothesis01
   (main (qualifier possibly may still be)
           (impairment of recent memory))
   (secondary none)
   (additional none))
)
(rule057
 (score (and (greaterp a (plus vmean 2))
             (greaterp s (plus vmean 2))
             (greaterp pc (plus pmean 2))))
 (hypothesis01
   (main (qualifier none) (paranoia))
   (secondary none)
   (additional none))
)
(rule058
 (observe (and (2 I) (5 E) (5 F)) )
 (hypothesis01
   (main (qualifier none) (antisocial personality disorder))
   (secondary none)
   (additional none))
)
(rule059
 (observe (2 J))
 (score (greaterp s (plus v 2)))
 (hypothesis01
   (main (qualifier none) (neurotic depression))
   (secondary none)
   (additional none))
)
```

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(rule060
  (score (and (greaterp cm (plus i 2)) (greaterp piq 100)))
  (hypothesis01
    (main (qualifier none) (hysterical features))
    (secondary none)
    (additional none))
)
(rule061
  (score (and (lessp a (difference vmean 2))
              (lessp cm (difference vmean 2))
              (or (equal ds vmean) (greaterp ds vmean))))
  (hypothesis01
    (main (qualifier none) (acute schizophrenic episode))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier none)
                    (chronic undifferentiated schizophrenia))
    (secondary none)
    (additional none))
)
(rule062
  (score (and (lessp a (difference v 2))
              (lessp ds (difference v 2))
            (greaterp a (plus ds 2)) ) )
  (hypothesis01
    (main (qualifier none) (neurosis))
    (secondary none)
    (additional none))
)
(rule063
  (score (and (lessp bd (difference pmean 2)) (lessp pmean 85)))
  (hypothesis01
    (main (qualifier none) (psychotic depression))
    (secondary none)
    (additional none))
)
(rule064
  (score (and (greaterp v (plus cm 2)) (greaterp i (plus cm 2))))
  (hypothesis01
    (main (qualifier none) (obsessive))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier none) (psychotic dpressives))
    (secondary none)
    (additional none))
  (hypothesis03
    (main (qualifier none) (psychotic))
    (secondary none)
    (additional none))
)
(rule065
  (score (and (lessp i (difference vmean 2))
              (lessp cm (difference vmean 2))))
  (hypothesis01
    (main (qualifier none) (psychopathology))
```

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      (secondary none)
      (additional none))
   )
   (rule066
    (score (and (lessp i (difference vmean 2))
                (lessp v (difference vmean 2))))
    (hypothesis01
      (main (qualifier none) (repressive tendency))
      (secondary none)
      (additional none))
   )
   (rule067
    (score (and (greaterp viq (plus piq 5))
                (lessp v (plus vmean 2))
                (greaterp pc (plus pmean 2)) ) )
    (hypothesis01
      (main (qualifier none) (hysteric))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (obsessive-compulsive))
      (secondary none)
      (additional none))
   )
   (rule068
    (score (and (greaterp v (plus pa 2))
                (or (equal pc pa) (greaterp pc (plus pa 1))
                    (greaterp pc (plus pa 2)))
                (or (equal pa oa) (lessp pa (difference oa 1))
                    (lessp pa (difference oa 2)) )
                (or (equal pa cd) (lessp pa (difference cd 1))
                    (lessp pa (difference cd 2)) ) ) )
    (hypothesis01
      (main (qualifier none) (depression))
      (secondary none)
      (additional none))
   )
   (rule069
    (score (and (lessp a (difference vmean 2))
                (lessp pc (difference pmean 2))
                (or (equal pa pmean) (greaterp pa pmean))))
    (hypothesis01
      (main (qualifier none) (character disorder))
      (secondary (qualifier including)
                              (and (antisocial personality)
                                   (addiction)))
      (additional none))
   )
   (rule070
    (observe (2 J))
    (score (and (lessp s (difference v 1))
                (lessp s (difference vmean 2))))
    (hypothesis01
      (main (qualifier none) (psychotic depression))
      (secondary none)
      (additional none))
   )
```

```
(rule071
  (score (and (greaterp i (plus vmean 2))
              (greaterp cm (plus vmean 2))
              (greaterp v (plus vmean 2)) ) )
  (hypothesis01
    (main (qualifier none) (intellectual striving))
    (secondary none)
    (additional none))
)
(rule072
  (observe (and (2 K)(2 L)(3 A)) )
  (score (greaterp fsiq 90))
  (hypothesis01
    (main (qualifier none) (and
                           (latent rather than acute schizophrenia)
                           (fantasies rather than delusions)))
    (secondary none)
    (additional none))

)
(rule073
  (score (and (greaterp a (plus vmean 2))
              (greaterp pc (pmean 2))))
  (hypothesis01                          \
    (main (qualifier possible) (paranoid alertness))
    (secondary none)
    (additional none))
)
(rule074
  (score (and (greaterp a (plus vmean 2))
              (greaterp s (plus vmean 2))
              (greaterp pc (plus pmean 2)) ) )
  (hypothesis01
    (main (qualifier none) (projective trend))
    (secondary none)
    (additional none))
)
(rule075
  (score (greaterp bd (plus pmean 2)))
  (test-retst (greaterp piq1 piq2))
  (hypothesis01
    (main (qualifier none) (paranoid schizophrenia))
    (secondary none)
    (additional none))
)
(rule076
  (score (and (greaterp bd (plus pmean 2)) (lessp piq 90)))
  (hypothesis01
    (main (qualifier none) (schizophrenia))
    (secondary none)
    (additional none))
)
(rule077
  (score (and (greaterp ds (plus vmean 2)) (greaterp piq 110)))
  (hypothesis01
    (main (qualifier none) (character disorders))
    (secondary none)
```

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         (additional none))
      (hypothesis02
         (main (qualifier none) (hysterics))
         (secondary none)
         (additional none))
   )
   (rule078
      (score (and (lessp a (difference vmean 2))
                  (greaterp ds (plus vmean 2)))))
      (hypothesis01
         (main (qualifier none) (or (schizoid personality)
                                    (schizoid character)))
         (secondary none)
         (additional none))
   )
   (rule079
      (score (greaterp ds (plus vmean 2)))
      (certain (neurosis))
      (hypothesis01
         (main (qualifier none) (ideational tendencies))
         (secondary none)
         (additional none))
   )
   (rule080
      (score (or (and (greaterp i (plus vmean 2))
                      (greaterp v (plus vmean 2))
                      (lessp cm (difference vmean 2))
                      (greaterp viq (plus piq 10)) )
                 (lessp s vmean)))
      (hypothesis01
         (main (qualifier none) (obsessive-compulsive neurosis))
         (secondary none)
         (additional none))
   )
   (rule081
      (observe (3 B))
      (score (greaterp pa (plus pmean 2)))
      (hypothesis01
         (main (qualifier tendency to)
               (antisocial personality disorder))
         (secondary none)
         (additional none))
   )
   (rule082
      (observe (and (2 M)(3 C)(3 I)) )
      (score (and (greaterp s (plus vmean 2))
                  (greaterp a (plus vmean 2))
                  (greaterp pc (plus pmean 2)) ) )
      (hypothesis01
         (main (qualifier none) (paranoid personality))
         (secondary none)
         (additional none))
   )
   (rule083
      (score (and (greaterp s (plus vmean 2))
                  (greaterp pc (plus pmean 2)) ) )
      (hypothesis01
```

```
      (main (qualifier none) (paranoid schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule084
   (observe (and (or (3 J)(5 E)) (3 K)) )
   (score (and (greaterp ds (plus vmean 2))
               (greaterp bd (plus pmean 2)) ) )
   (hypothesis01
      (main (qualifier none)(antisocial personality disorder))
      (secondary none)
      (additional none))
  )
  (rule085
   (score (and (greaterp bd (plus vmean 2))
               (greaterp bd (plus pmean 2)) ) )
   (hypothesis01
      (main (qualifier none) (schizoid))              .
      (secondary none)
      (additional none))
   (hypothesis02
      (main (qualifier none) (schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule086
   (score (and (greaterp a (plus vmean 2))
               (greaterp ds (plus vmean 2)) ) )
   (hypothesis01
      (main (qualifier possible) (or (obsessive-compulsive)
                                     (schizoid tendency)))
      (secondary none)
      (additional none))
  )
  (rule087
   (score (and (greaterp i (plus vmean 2))
               (or (lessp v (difference vmean 1))
                   (lessp v (difference vmean 2))
                   (lessp v (difference vmean 3)) ) ) )
   (hypothesis01
      (main (qualifier none) (latent schizophrenia))
      (secondary none)
      (additional none))
   (hypothesis02
      (main (qualifier none) (simple schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule088
   (score (and (greaterp i (plus vmean 2))
               (greaterp v (plus vmean 2))
               (lessp cm (difference vmean 2))
               (lessp s (difference vmean 2))
               (lessp ds (difference vmean 2)) ) )
   (hypothesis01
      (main (qualifier none) (obsessive-compulsive))
      (secondary none)
```

```
        (additional none))
    (hypothesis02
      (main (qualifier none) (psychotic depression))
      (secondary none)
      (additional none))
    (hypothesis03
      (main (qualifier none) (undifferentiated schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule089
    (score (and (greaterp oa (plus pmean 2))
                (lessp pmean (difference pmean 2))
                (lessp pa (difference pmean 2))
                (lessp bd (difference pmean 2))
                (lessp cd (difference pmean 2)) ) )
    (hypothesis01
      (main (qualifier none) (blandness))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule090
    (score (and (greaterp v (plus vmean 2))
                (greaterp viq (plus piq 5))
                (lessp pc (difference pmean 2)) ) )
    (hypothesis01
      (main (qualifier none) (intellectualizing psychotic))
      (secondary none)
      (additional none))
  )
  (rule091
    (observe (and (3 E)(3 L)) )
    (score (and (greaterp bd (plus pmean 2))
                (greaterp oa (plus pmean 2)) ) )
    (hypothesis01
      (main (qualifier none) (acute paranoid schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule092
    (observe (and (3 F)(4 M)(4 N)) )
    (score (greaterp fsiq 110))
    (hypothesis01
      (main (qualifier none) (simple schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule093
    (observe (and (3 G)(4 K)(4 L)(5 A)(5 B)(5 C)(5 G)) )
    (hypothesis01
      (main (qualifier none) (depression))
      (secondary none)
      (additional none))
```

```
)
(rule094
  (observe (and (5 B)(5 C)) )
  (hypothesis01
    (main (qualifier none) (paranoia))
    (secondary none)
    (additional none))
)
(rule095
  (score (and (lessp s (difference vmean 2))
              (lessp a (difference vmean 2))
              (lessp cm (difference vmean 2))
              (lessp ds (difference vmean 2))))
  (hypothesis01
    (main (qualifier none) (depression))
    (secondary none)
    (additional none))
)
(rule096
  (observe (and (4 A)(5 H)(5 I)) )
  (hypothesis01
    (main (qualifier none) (antisocial personality disorder))
    (secondary none)
    (additional none))
)
(rule097
  (score (and (lessp a (difference vmean 2))
              (greaterp cm (plus vmean 2)) ) )
  (hypothesis01
    (main (qualifier none) (contraindicates psychotic depression))
    (secondary none)
    (additional none))
)
(rule098
  (score (and (lessp i (difference cm 2)) (greaterp piq 100)
              (greaterp piq viq) ) )
  (hypothesis01
    (main (qualifier none) (hysterical features))
    (secondary none)
    (additional none))
)
(rule099
  (observe (4 B))
  (hypothesis01
    (main (qualifier none) (schizophrenia))
    (secondary none)
    (additional none))
)
(rule100
  (observe (4 C))
  (hypothesis01
    (main (qualifier possible)
               (chronic undifferentiated schizophrenia))
    (secondary none)
    (additional none))
)
(rule101
```

```
      (score (and (lessp ds (difference vmean 2))
                  (lessp oa (difference pmean 2)))))
      (hypothesis01
        (main (qualifier none) (depression))
        (secondary none)
        (additional none))
      (hypothesis02
        (main (qualifier none) (tension))
        (secondary none)
        (additional none))
  )
  (rule102
    (score (and (lessp oa (difference pmean 2))
                (lessp pc (difference pmean 2)))))
    (hypothesis01
      (main (qualifier none) (or (acute schizophrenic episode)
                             (chronic undifferentiated schizophrenia)))
      (secondary none)
      (additional none))
  )
  (rule103
    (score (and (lessp piq 90) (lessp s (difference vmean 2)) ) )
    (hypothesis01
      (main (qualifier none) (paranoid schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule104
    (score (and (lessp pa (difference pmean 2))
                (lessp s (difference vmean 2))))
    (hypothesis01
      (main (qualifier none)
                        (chronic undifferentiated schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule105
    (score (and (lessp v (difference vmean 2))
                (greaterp oa 10) (greaterp cd 10)))
    (hypothesis01
      (main (qualifier none) (simple schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule106
    (score (and (greaterp vscatter 5) (greaterp pscatter 5) ) )
    (hypothesis01
      (main (qualifier none) (schizophrenic tendency))
      (secondary none)
      (additional none))
  )
  (rule107
    (observe (4 D))
    (score (and (greaterp pc 7) (greaterp pa 7) (greaterp cd 7)
                (lessp bd (difference pmean 1))
                (greaterp bd (difference pmean 4))
                (lessp oa (difference pmean 1))
```

```
                  (greaterp oa (difference pmean 4)))))
   (hypothesis01
     (main (qualifier none) (tension))
     (secondary none)
     (additional none))
 )
 (rule108
  (observe (4 E))
  (score (or (lessp ds (difference vmean 4))
             (lessp a (difference vmean 4))
             (lessp pc (difference pmean 4)) ) )
  (hypothesis01
     (main (qualifier none) (latent schizophrenia))
     (secondary none)
     (additional none))
 )
 (rule109
  (score (and (lessp a (difference vmean 2))
              (greaterp pa (plus pmean 2))
              (or (equal viq piq) (lessp viq piq) ) ) )
  (hypothesis01
     (main (qualifier none) (narcissistic character disorder))
     (secondary none)
     (additional none))
 )
 (rule110
  (score (and (lessp i (difference vmean 2))
              (greaterp cm (plus vmean 2))
              (or (equal viq piq) (lessp viq piq) ) ) )
  (hypothesis01
     (main (qualifier none) (hysteria))
     (secondary none)
     (additional none))
 )
 (rule111
  (score (and (greaterp a (plus pmean 2))
              (greaterp i (plus pmean 2)) ) )
  (hypothesis01
     (main (qualifier none) (depression))
     (secondary none)
     (additional none))
 )
 (rule112
  (score (and (greaterp v (plus vmean 2)) (lessp viq 91)
              (lessp piq 91) ) )
  (hypothesis01
     (main (qualifier none) (alcohol addiction))
     (secondary none)
     (additional none))
 )
 (rule113
  (observe (3 F))
  (score (greaterp fsiq 110))
  (hypothesis01
     (main (qualifier none) (schizophrenia))
     (secondary none)
     (additional none))
```

```
)
(rule114
  (score (and (lessp pc (difference bd 2))
              (lessp pc (difference oa 2))
              (lessp pc (difference cd 2))
              (lessp pa (difference bd 2))
              (lessp pa (difference oa 2))
              (lessp pa (difference cd 2))
              (greaterp bd (plus pmean 2))
              (greaterp oa (plus pmean 2))
              (greaterp cd (plus pmean 2))
              (lessp a (difference vmean 2))
              (lessp cm (vmean 2)) ) )
  (hypothesis01
    (main (qualifier none) (simple schizophrenia))
    (secondary none)
    (additional none))
)
(rule115
  (score (and (lessp i (difference v 2))
              (lessp s (difference v 2))
              (lessp a (difference v 2))
              (greaterp v (plus cm 2))
              (greaterp v (plus ds 2))
              (greaterp bd (plus pmean 2))
              (greaterp oa (plus pmean 2))
              (lessp ds (difference vmean 2))
              (lessp pc (difference pmean 2))
              (lessp pa (difference pmean 2))))
  (hypothesis01
    (main (qualifier none) (acute schizophrenic episode))
    (secondary none)
    (additional none))
  (hypothesis02
    (main (qualifier none)
                     (chronic undifferentiated schizophrenia))
    (secondary none)
    (additional none))
)
(rule116
  (score (and (lessp s (difference vmean 2))
              (lessp a (difference (vmean 2))))))
  (certain (schizophrenia))
  (hypothesis01
    (main (qualifier none) (chronicity))
    (secondary none)
    (additional none))
)
(rule117
  (score (greaterp cm (plus vmean 2)) )
  (certain (schizophrenia))
  (hypothesis01
    (main (qualifier none) (paranoid schizophrenia))
    (secondary none)
    (additional none))
)
(rule118
```

```
      (score (and (greaterp i 10) (greaterp cm 10) (lessp s cm)
                (lessp v (difference cm 2)) (greaterp i (plus s 2))
                (greaterp i (plus v 2)) ) )
    (bckgrnd (5 J))
    (hypothesis01
      (main (qualifier none) (intellectual striving))
      (secondary none)
      (additional none))
  )
  (rule119
    (score (and (greaterp oa 10) (greaterp ds 10) ) )
    (certain (schizophrenia))
    (hypothesis01
      (main (qualifier none) (blandness))
      (secondary none)
      (additional none))
  )
  (rule120
    (score (and (lessp a (difference vmean 2))
                (lessp pc (difference pmean 2))))
    (hypothesis01
      (main (qualifier none) (schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule121
    (score (and (lessp v (difference vmean 2))
                (lessp viq (difference piq 10))))
    (hypothesis01
      (main (qualifier none)
                      (chronic undifferentiated schizophrenia))
      (secondary none)
      (additional none))
    (hypothesis02
      (main (qualifier none) (psychotic depression))
      (secondary none)
      (additional none))
  )
  (rule122
    (score (and (lessp ds (difference vmean 2))
                (lessp pc (difference pmean 2))
                (lessp pa (difference pmean 2)) ) )
    (hypothesis01
      (main (qualifier possible) (schizophrenia))
      (secondary none)
      (additional none))
  )
  (rule123
    (score (lessp i (difference cm 2)) )
    (certain (psychosis))
    (hypothesis01
      (main (qualifier none) (paranoid))
      (secondary none)
      (additional none))
  )
  (rule124
    (score (and (greaterp viq (plus piq 5)) (greaterp vscatter 3)
```

```
                       (lessp vscatter 6) ) )
   (hypothesis01
     (main (qualifier tendency to) (neurosis))
     (secondary none)
     (additional none))
 )
 (rule125
   (score (and (lessp pa (difference bd 3))
               (lessp pa (difference oa 3))
               (lessp pc (difference bd 3))
               (lessp pc (difference oa 3)) ) )
   (hypothesis01
     (main (qualifier none) (schizophrenia))
     (secondary none)
     (additional none))
 )
 (rule126
   (score (and (lessp pa (difference bd 3))
               (lessp pa (difference oa 3))
               (lessp pc (difference bd 3))
               (lessp pc (difference oa 3))
               (lessp cm 10) ) )
   (hypothesis01
     (main (qualifier none) (paranoid schizophrenia))
     (secondary none)
     (additional none))
 )
 (rule127
   (observe (and (4 F)(9 A)) )
   (hypothesis01
     (main (qualifier none) (acute schizophrenia))
     (secondary (qualifier if occurs to a mild degree)
                    (incipient schizophrenia))
     (additional none))
 )
 (rule128
   (observe (and (9 A)(10 J)) )
   (hypothesis01
     (main (qualifier none) (stable borderline state))
     (secondary none)
     (additional none))
 )
 (rule129
   (observe (9 B))
   (hypothesis01
     (main (qualifier none)
                       (feelings of being looked at or criticized))
     (secondary none)
     (additional none))
 )
 (rule130
   (observe (9 C))
   (hypothesis01
     (main (qualifier none) (organic brain syndrome))
     (secondary none)
     (additional none))
 )
```

```
(rule131
 (observe (9 D))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule132
 (observe (9 E))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule133
 (observe (9 F))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule134
 (observe (9 G))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule135
 (observe (9 H))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule136
 (observe (9 I))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule137
 (observe (9 J))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule138
 (observe (9 K))
 (hypothesis01
   (main (qualifier none) (organic brain syndrome))
   (secondary none)
   (additional none))
)
(rule139
```

```
   (observe (2 H))
   (hypothesis01
      (main (qualifier none) (psychosis))
      (secondary none)
      (additional none))
)
(rule140
  (observe (10 C))
  (hypothesis01
      (main (qualifier none) (organic brain syndrome))
      (secondary none)
      (additional none))
)
(rule141
  (observe (and (5 D)(10 D)) )
  (hypothesis01
      (main (qualifier none) (organic brain syndrome))
      (secondary none)
      (additional none))
)
(rule142
  (observe (10 E))
  (hypothesis01
      (main (qualifier none) (organic brain syndrome))
      (secondary none)
      (additional none))
)
(rule143
  (observe (10 F))
  (hypothesis01
      (main (qualifier none) (antisocial personality disorder))
    (secondary none)
    (additional none))
)
(rule144
  (observe (10 G))
(hypothesis01
      (main (qualifier none) (antisocial personality disorder))
      (secondary none)
      (additional none))
)
(rule145
  (observe (10 H))
(hypothesis01
      (main (qualifier none) (antisocial personality disorder))
      (secondary none)
      (additional none))
)
(rule146
  (observe (10 I))
(hypothesis01
      (main (qualifier none) (antisocial personality disorder))
      (secondary none)
      (additional none))
)
))
```

Appendix B

```
(asetq top-common '(
^For each test observation or piece of background information known to be^
^true for the examinee, select the letter which precedes it.  Hit the plus^
^sign when all selections have been made.^
^PRESS:      FOR:^
)                  )
(asetq bottom-common '(
^Again, type the plus sign when you have made all applicable selctions^
^from this menu, just the plus sign, and then hit RETURN.^
^Your selections from this menu were:^
)                   )
(asetq inpmen0 nil)
(asetq inpmen1 '(
^Enter the scaled subtest scores and IQs from the WAIS, in the order on which^
^they appear on the from cover, plus the requested raw scores.  If a score is^
^not present, due to lack of subtest administration or validty, enter 99.^
^Order of entry should be:^
^Verbal subtest scores^
^Performance subtest scores^
^IQs^
^Digits Forward raw score^
^Digits Backward raw score^
)           )
(asetq inpmen2 '(
^A   Failure of easy Similarities items, with subsequent passes^
^B   Failure of easy Picture Completion items, with subsequent passes^
^C   Failure of easy Information items, with subsequent passes^
^D   Inability to perform Digit Span backwards^
^E   DK responses to Comprehension^
^F   Missing easy Arithmetic items, with subsequent passes^
^G   Ability to work effectively and appropriately^
^H   Cognitive disruption, with strange, morbid, otherworldly content^
^I   Clang associations on Vocabulary^
^J   Clinical evidence of depression^
^K   Evidence of apprehension^
^L   Evidence of withdrawal due to fantasy^
^M   Preoccupation with minutia^
)              )
(asetq inpmen3 '(
^A   No schizophrenic verbalizations^
^B   Flippancy^
^C   Overmeticulous verbalization^
^D   Impulsive guessing on whole test^
^E   Inertia^
^F   Wild guessing^
^G   Lack of qualification^
^H   Limited perceptual distortions on Picture Arrangement and Picture^
^    Completion^
^I   Frequently gave irrelevant details^
^J   Impulsive guessing on Information and Vocabulary^
^K   Moralizing comments on Comprehension^
^L   Inability to concentrate on Arithmetic^
)           )
(asetq inpmen4 '(
^A   Good visual-motor coordination^
```

```
^B  Confused object identification on Picture Completion^
^C  Failure on easy Information items, with subsequent passes^
^D  Rapid responses^
^E  Orderly responses, possibly occasional odd verbalizations^
^F  Anxiety^
^G  Presence of verbal word salad^
^H  Schizophrenia certain (from previous evaluation)^
^I  Psychosis certain (from previous evaluation)^
^J  Neurosis certain (from previous evaluation)^
^K  Lack of verbal fluency^
^L  Few peculiar verbalizations^
^M  Bland guessing^
^N  Perceptual vagueness^
)               )
(asetq inpmen5 '(
^A  Self-criticality^
^B  A few perceptual distortions on Picture Arrangement^
^C  A few perceptual distortions on Picture Completion^
^D  Missing easy Comprehension items, with subsequent passes^
^E  No serious hearing impairment^
^F  Supercilious attitude^
^G  Lack of elaboration^
^H  Good visual-motor speed^
^I  A schemer^
^J  Restricted formal education^
^K  History of anxiety attacks or an observed attack^
^L  Grossly impaired reality contact^
^M  Reality contact good^
)               )
(asetq inpmen6 '(
^A  Onset of presenting problem immediately followed an extremely^
^   stressful situation^
^B  Response to a crisis with depression or anxiety^
^C  Auditory hallucinations^
^D  Dynamic processes, rather than simple inability to maintain reality^
^   contact, responsible for impairment^
^E  Good family relationships^
^F  Onset of problem late in life^
^G  Has taken appreciable quantities of psychedelic drugs^
^H  History of psychosis, but presently in remission^
^I  Lacks consideration for other people's feelings and rights^
^J  History of violent behavior^
^K  Lives predominately for immediate gain or pleasure^
^L  Overt hostility toward the examiner^
)               )
(asetq inpmen7 '(
^A  Challenged examiner's authority, at least half-seriously^
^B  Overly active conscience^
^C  Normally active conscience^
^D  Specific gross inabilities present^
^E  Had trouble attaching names to objects during examination^
^F  Had difficulty finding words to express ideas, as opposed to lack^
^   of ideas^
^G  Signs of aphasia, other than two immediately preceding signs^
^H  Perseveration, motor or ideational or both^
^I  Rotations on Block Design, even after demonstration^
^J  Fluctuating ability to retrieve facts in memory, such as own name^
```

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^K   Severe motor handicaps^
^L   Slow motor speed^
^M   No sign of obvious organic insult in a thorough and reliable history^
^N   Global impression of mental retardation^
)            )
(asetq inpmen8 '(
^A   Lack of or incorrect responses due to absence of information, rather^
^    than bizarreness^
^B   Obvious presence of Down's Syndrome^
^C   Prior evaluation concluded mental retardation^
^D   Showed at least some lack of acceptance of failure^
^E   Completed at least one year of college^
^F   Showed extraordinary motor skill^
^G   Impression of higher ability than immediately apparent^
^H   Prior high occupational achievement^
^I   Prior high scholastic achievement^
^J   Extraordinary quality of definitions on Vocabulary^
^K   Ingenious problem-solving methods^
^L   Very active curiosity and fascination with surroundings^
^M   Made good guesses or approximations on failed items^
^N   If in school, teacher endorses as gifted^
)                )
(asetq inpmen9 '(
^A   Blurring of boundaries between separate categories, thoughts,^
^    feelings, or experiences^
^B   Introduction of eyes where none exist, or emphasis on existing eyes^
^C   Difficulty with abstract concept formation^
^D   Difficulty with hypothetical thinking^
^E   Difficulty in keeping track of a train of thought or progress on a^
^    task^
^F   Recognition of poor responses, with desire to change them, but^
^    unable to make needed changes^
^G   Figure-ground reversals^
^H   Confused directionality, such as up-down, left-right, east-west, etc.^
^I   Confabulation^
^J   Instances where the way to do something was obviously known, but^
^    could not put that knowledge into action.^
^K   Difficulties did not reflect psychological embellishment and^
^    thematic richness^
)                )
(asetq inpmen10 '(
^A   Cognitive disruption, with obvious struggle to form rather mundane^
^    thoughts or concepts^
^B   Withdrawal from conventional modes of experience^
^C   Particular difficulty with Comprehension's proverbs^
^D   Frequent misinterpretation of questions^
^E   Understood what was expected, but difficulty in execution^
^F   Polite, measured tone of interaction^
^G   Impression of hyperalertness and watchfulness^
^H   Mistrust of examiner and not under evaluation for criminal^
^    proceedings^
^I   Felt put upon if put under even mild pressure or when failing^
^J   Little or no anxiety^
)                )
(asetq inpmen11 '(
^A   Bizzare and remote associations^
)                )
```

Appendix C

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;These are the rules for superqualifiers and disqualifiers.  Very briefly,
;superqualifiers are signs found in an individual examinee, which, if all are
;present,  elevate the clinical entity associated with those signs to pre-
;eminence.  Other evidence does need to be examined, even if a set of
;superqualifiers are present, because that other evidence will provide other
;implications which might assist in diagnosis refinement or provide areas
;which might be explored in further testing or therapy, or some combination
;of those.  Disqualifier sets are just the opposite.  If a full disqualifier
;set is present, it suggests that the clinical entity associated with it is
;not present.  Evidence other than test scores is represented as a two-element
;list, where the first list element is the number of the menu in FIXDATA LISP
;on which the item of evidence occurs.  The second list element is the key or
;item-number on that particular menu.  For example, the first such list, just
;below, is   5 K.  The  5  means that the item is on the fifth input menu,
;which would be  inpmen5 , and the  K  means that the key to select the item
;is  K  .  The item itself is
;            History of anxiety attacks or an observed attack
;The LISP basic functions  and,  or,  and   not  mean what they usually mean.
;
(asetq sd-qualifiers '(
   (neurosis
     (disqualifiers (and (5 L)(6 A)) )
     (superqualifiers (and (5 K)(5 M)(6 B)) ) )
   (psychosis
     (disqualifiers (and (5 M)(6 D)(6 E)(6 F)(not (6 H))(not (6 S))
                      (or (8 H)(8 I)) ) )
     (superqualifiers (and (6 C)(6 D)) ) )
   (antisocial-personality-disorder
     (disqualifiers (or (7 B)(7 C)) )
     (superqualifiers (and (5 M)(6 I)(6 J)) ) )
   (organic-brain-syndrome
     (disqualifiers (and (4 G)(6 D)(7 M)(11 A)))
     (superqualifiers (and (7 D)(or (7 E)(7 F)(7 G))) ) )
   (mental-retardation
     (disqualifiers (or (greaterp fsiq 69)
                      (and (lessp fsiq 70)(8 G))) ) )
     (superqualifiers (and (lessp fsiq 70)(7 N)(8 B)) ) )
   (giftedness
     (disqualifiers nil)
     (superqualifiers (and (greaterp fsiq 129)(or (8 G)(8 I))) ) )
)         )
```

Appendix D

Inference Engine Algorithm

DATA:

APPLICABLE SIGN RULES   The sign rules which were fired for a
                            given case

SD-QUALIFIERS   A list of clinical entities and the data which,
                if present will either elevate a clinical entity
                to superqualifier or discard status

SUPERQUALIFIERS   Those clinical entities which are considered
                      by the system to be present, because the data
                      which very strongly suggest their presence
                      applies to the case under consideration

CLINICAL ENTITIES LIST   The list of clinical entities under
                         consideration, the set of all entities
                         known to the system, minus the
                         disqualified entities

SCORES   A list of the WAIS test scores, consists of type of
          score, subtest, IQ, or other paired with the numerical
          value of the score

MENU SELECTIONS   The list of all of the input menu items
                      chosen as applicable to the case under
                      consideration

OBSERVATIONS SIGN RULES   A list of the sign rules in which the
                          evidence was obtained from the
                          psychologist's observations during
                          WAIS administration. These rules apply
                          to the examinee under consideration by
                          the system.

SCORE SIGN RULES   A list of the sign rules in which the
                     evidence consists of WAIS score patterns.
                     These rules apply to the examinee under
                     consideration by the system.

BACKGROUND SIGN RULES   A list of the sign rules in which the
                         evidence consists of background
                         information on the examinee. These
                         rules apply to the examinee under
                         consideration by the system.

OBSERVATIONS SUPPORT   A list of elements containing a clinical
                         entity, rule number, and the first
                         hypothesis number
                         which supports the notion of the
                         presence of a clinical entity. All
                         rules in this list are based on
                         observations

SCORES SUPPORT   As above, for the WAIS scores

BACKGROUND SUPPORT   As above, for background information

FOUND   A "boolean" variable

ALGORITHM:

While not the end of SD-QUALIFIERS list do:

     For each clinical entity in SD-QUALIFIERS
          If superqualifying evidence is present in MENU
               SELECTIONS list and/or SCORES list
          Then put name of clinical entity into
               SUPERQUALIFIERS list

          If disqualifying evidence is present in MENU SELECTIONS
               list and/or SCORES list
          Then remove name of clinical entity from CLINICAL
               ENTITIES LIST

End While not the end of SD-QUALIFIERS list

While not the end of APPLICABLE SIGN RULES do

     While not the end of each rule's the evidence section do

          If the type of evidence in the top part of the rule =
               "score"
          Then put the rule into SCORE SIGN RULES list

          If the type of evidence in the top part of the rule =
               "bckgrnd" or "sochist"
               Then put the rule into BACKGROUND SIGN RULES list

          If the type of evidence in the top part of the rule =
               "observe"
               Then put the rule into OBSERVATIONS SIGN RULES
                    list
          If the type of evidence in the top part of the rule =
               "certain"
               Then put the rule into MIGHT ADD SIGN RULES

     End While not end of each rule's evidence section

End While not the end of APPLICABLE SIGN RULES

While not the end of CLINICAL ENTITIES LIST do
     Create three lists for each clinical entity, OBSERVATIONS
          SUPPORT, SCORES SUPPORT, and BACKGROUND SUPPORT

     Create three more lists for each clinical entity,
          OBSERVATIONS MIGHT ADD, SCORES MIGHT ADD, and
          BACKGROUND MIGHT ADD

```
        Set FOUND to "false"


    While not the end of OBSERVATIONS SIGN RULES do

        While not the end of the hypotheses in each rule do
            If the hypothesis names one of the clinical
                entities
                Then put the name of that entity, the
                    rule number, and hypothesis number into
                    OBSERVATIONS SUPPORT list, and set FOUND
                    to "true"
            If the hypothesis names "schizophrenia" as an
                hypothesis
                Then put "psychosis", the rule number, and
                    hypothesis number into OBSERVATIONS
                    SUPPORT list,

    End While not the end of OBSERVATIONS SIGN RULES

    If FOUND = "false"
        Then put clinical entity and rule number into
        OBSERVATIONS NO SUPPORT list

    Repeat the above While loop for the SCORES SUPPORT list,
        and the BACKGROUND SUPPORT list

End while not the end of CLINICAL ENTITIES LIST

For each clinical entity in CLINICAL ENTITIES LIST, do

    Create OBSERVATIONS-SUPPORT-COUNT, SCORES-SUPPORT-COUNT, and
        BACKGROUND-SUPPORT-COUNT lists, put in all clinical
        entities left in the CLINICAL ENTITIES LIST

Remove all rules in MIGHT ADD list from APPLICABLE SIGN RULES

For each rule in the APPLICABLE SIGN RULES list do
    Search the OBSERVATIONS SUPPORT lists of all entities
        for the rule number
    If the rule number matches the one from APPLICABLE SIGN
        RULES
        Then If LOWEST-HYPOTHESIS-NUMBER is still nil
            {first hypothesis found} or hypothesis
            number of hypothesis just found is less
            than LOWEST-HYPOTHESIS-NUMBER
                Then:
                    Set LOWEST-HYPOTHESIS-NUMBER to the
                    hypothesis number in the
                    OBSERVATIONS SUPPORT
                    list

                    Set BEST-HYPOTHESIS to the clinical
                    entity whose OBSERVATIONS SUPPORT
                    list the hypothesis number was
```

found in

If the rule was found
        Then increment the count for entity whose name
            matches BEST-HYPOTHESIS in OBSERVATIONS-
            SUPPORT-COUNT

   If the rule number was not found in OBSERVATIONS
        SUPPORT
        Then repeat the above process for the SCORES
            SUPPORT and SCORES-SUPPORT-COUNT lists
   If the rule number was not found in the SCORES SUPPORT
        list
        Then repeat the above process for the BACKGROUND
            SUPPORT and BACKGROUND-SUPPORT-COUNT lists

   End For each rule in APPLICABLE SIGN RULES

End While not the end of the APPLICABLE SIGN RULES

Put the name of any superqualifier(s), along with supporting
    evidence from OBSERVATIONS SUPPORT, SCORES SUPPORT, and
    BACKGROUND SUPPORT into the output list. Label as
    superqualifiers.

If the entity with the highest count in the OBSERVATIONS-SUPPORT-
    COUNT list is not in the SUPERQUALIFIERS list
    Then:
        Put that entity's name into the output list, labelled
            as the entity best supported by observations
            alone
        Search the MIGHT ADD list for the above entity, and add
            the information from it after the material given
            just above

If the entity with the highest count in the SCORES-SUPPORT-LIST
    has the first- or second-highest count in OBSERVATIONS-
    SUPPORT-COUNT
    Then:
        Put it into the output list, labelling it as the entity
            best supported by the observations and scores
            combined
        Search the MIGHT ADD list for the above entity, and add
            the information from it after the material given
            just above

If the entity with the highest count in the BACKGROUND-SUPPORT-
    LIST has the first- or second-highest count in OBSERVATIONS-
    SUPPORT-COUNT
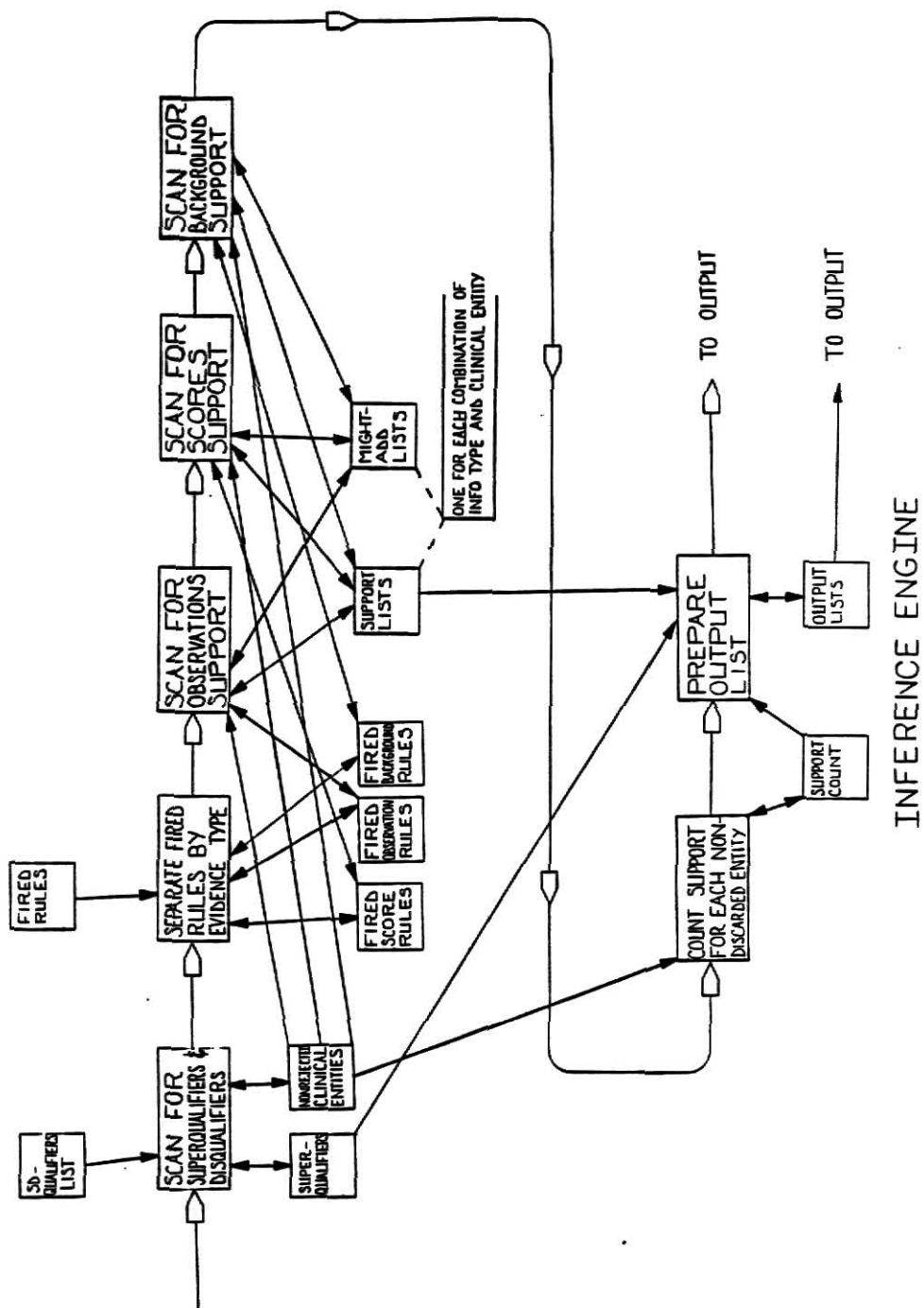   Then:
        Put it into the output list, labelling it as the entity
            best supported by the observations and background
            information combined
        Search the MIGHT ADD list for the above entity, and add
            the information from it after the material given

just above

Appendix E

INFERENCE ENGINE

DAVE: AN EXPERT SYSTEM FOR THE ANALYSIS OF
THE WECHSLER ADULT INTELLIGENCE SCALES AND RELATED INFORMATION

by

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ABSTRACT

Artificial-intelligence (AI) expert systems have been developed for a number of applications in the recent past. One type of application has been the diagnosis of physical diseases. DAVE, the expert system described in this paper, is a diagnostic system which uses part of the information available to a clinical psychologist who is confronted with the problem of diagnosing mental disorders. Specifically, that information consists of the scores from the Wechsler Adult Intelligence Scales (WAIS), the accompanying observations, and any reliable background information which may be available. Clinicians usually give other tests after the WAIS. Even though the psychological examination is not complete after the administration of the WAIS and the analysis of the allied information, the clinician may believe that one or more clinical entities, i.e., neurosis, psychosis, antisocial personality disorder, organic brain syndrome, mental retardation, or giftedness, are very likely to be present in the examinee. Thus, the WAIS and the accompanying information is used to formulate tentative hypotheses for further exploration. DAVE is designed to formulate those tentative hypotheses, thus providing the clinician with the advantages inherent in the automation of a repetitive and routine task.

This paper first gives a brief overview of the applicable clinical psychology background, and then discusses some of the issues in knowledge engineering. Knowledge engineering is the discipline which organizes knowledge from other academic and applied disciplines in a manner which allows that other knowledge to be represented and used on a computer. DAVE's overall design is then described, and the description includes the processes and

the major fixed knowledge structures used by those processes. DAVE's limitations are then discussed. The conclusions summarize DAVE's design and the major assumptions and principles under which DAVE was created, and suggest further work which might be done on DAVE and applications in psychology in general.