3

Worker-Oriented Methods

In this chapter, we describe job analysis methods that focus on attributes or characteristics that people need to be able to complete their jobs successfully. One of the main uses of such information is to hire qualified people. Often the attributes refer to the person and might be considered psychological characteristics. For example, some characteristics are perceptual, such as use of color vision or sense of touch. Others refer to mental processes, such as arithmetic reasoning or speaking a foreign language. Still others refer to skill in using tools or equipment, such as a violin or a forklift. There is another class of attributes covered in worker-oriented methods that refers more to the context of work, and these are shorthand ways of saying that a person needs to have whatever is needed to cope with the job. For example, a person may need the ability to work alone or to work in noisy or dusty environments. Sometimes the abilities become more or less synonymous with the task, such as the ability to weld or to dance. In such cases, it is difficult to determine whether we are talking about the work or the worker. But in this chapter, the *intent* of the job analysis procedure is to describe jobs from the worker's point of view rather than the work itself.

In some ways, worker-oriented methods are the most "psychological" of the methods of job analysis. The psychology comes from attempting to determine what it takes to be good at a job. We are sometimes amazed at how skilled human performance can be. For example, we have been amazed watching a professional figure skater (that looks so effortless!), a guitar player knocking out a tasty riff (how does he do that?), or an astronomer pointing out features of some celestial object (how could she possibly know anything about a quasar?). What is it about these people that makes them so good at what they do? Of course, they have spent years practicing their specialty, but do they also possess something special, some needed capacity? On the other hand, are there some things that we are unlikely ever to be really be good at, regardless of the time spent? Could it be drawing, tennis, calculus, poetry, or playing the violin? One of us (Brannick) will never progress beyond drawing stick figures.

What does it take to be good at a job, and how do we find this out? That is the topic of this chapter. Job analysts have generally agreed to capture these human attributes by referring to KSAOs (knowledge, skill, ability, and other personal characteristics). There are several ways of defining these human attributes. One approach was offered by Levine (1983). We adapt those definitions here. *Knowledge* is the existence in memory of a retrievable set of technical facts, concepts, language, and procedures directly relevant to job performance. *Skill* is the developed or trained capacity to perform tasks that call for the use of tools, equipment, or machinery. *Abilities* involve the relatively enduring capacity to acquire skills or knowledge, and to carry out tasks at an acceptable level of proficiency where tools, equipment, and machinery are not major elements. Finally, *other personal characteristics* include job-relevant interests, preferences, temperament, and personality characteristics that indicate how well an employee is likely to perform on a routine, day-to-day basis or how an employee is likely to adjust to a job's working conditions. (If you casually drop the term "KSAOs" among job analysts they will immediately accept you into their secret society, even if you don't know the secret handshake.)

Several different techniques are described in this chapter. First, we describe the *job element method* (JEM). JEM is the earliest of the worker-oriented methods. It blurs the distinction between what gets done and what abilities are required to do the job. This method breaks a job down into pieces called *elements* (small surprise there) that are described in terms that job incumbents can easily understand. But note that these elements are very different from the elements we discussed in Chapter 2.

Next we turn to the *Position Analysis Questionnaire* (PAQ). The PAQ was developed with the notion that it should be applied to a wide variety of jobs. The PAQ was developed over years of study and has been applied to a very large number of jobs since its development. You might say that the PAQ is a famous name in the business of job analysis. The PAQ lists a large number of standard elements (for example, the job requires standing; it also uses the term *element* to mean something a bit different; here "element" is just an item to respond to) that the job analyst records on a specially designed form.

We then turn to other trait-based worker-oriented methods. We briefly describe three methods that focus on other standard lists of human abilities, the *Threshold Traits Analysis System* (TTAS), the *Ability Requirements Scales* (ARS), and the *Occupational Reinforcer Pattern* (ORP). The list of traits in the TTAS is global and comprehensive. The list is useful, among other things, for keeping you from overlooking something important. The abilities covered by the Ability Requirements Scales (see Table 3.6 later in the chapter for a sample of these) are each linked to one or more psychological tests. The Occupational Reinforcer Pattern characteristics are linked to human motives at work that can be used for vocational purposes. The other two methods in this section are noted for their attention to tools and equipment. The methods are the *AET*

(*Arbeitwissenschaftliches Erhebungsverfahren zur Tätigkeitsanalyse;* we will translate for you later so you can get this right on a TV quiz show) and the *Job Components Inventory* (JCI). The AET, which, as you may have guessed, was developed in Germany, looks at jobs from a human engineering standpoint and asks how the job might be done in such a way that it is more friendly to the worker. The Job Components Inventory lists 220 items related to tools and equipment.

Finally, we describe methods used in *cognitive task analysis.* Cognitive task analysis is the most recently developed of the worker-oriented techniques. Cognitive task analysis attempts to gain a better understanding of the mental processes and strategies that are used in completing the job. To do so, cognitive task analysis often focuses on the difference between novice and expert performance on the job.

The common thread through all the worker-oriented techniques is the focus on the qualities workers must have to be successful.

Job Element Method

JEM is probably the earliest of the worker-oriented job analysis approaches. It was developed in the 1950s by Ernest Primoff and associates in the U.S. Civil Service Commission (now the U.S. Office of Personnel Management, Office of Personnel Research and Development; see Primoff, 1957). JEM is the worker-oriented method that is most similar to the work-oriented methods. JEM focuses on work behaviors and the results of this behavior rather than more abstract characteristics. An *element* in JEM is a combination of behaviors and associated evidences. Elements are named through terms commonly used in the workplace rather than terms developed by psychologists. For example, "the behavior of acting in a dependable fashion, evidenced by punctuality, commendations for dependability and a record of doing exactly what is required by the job, is an element termed Reliability" (Primoff & Eyde, 1988, p. 807).

CONTENT OF ELEMENTS

Elements cover a broad range of behaviors, including cognitive, psychomotor, and work habits. Cognitive elements include such items as recognizing tools and their uses, reading blueprints, and computing means and standard deviations. The psychomotor elements include the ability to sense and perceive (for example, color vision) and to carry out simple to complex motor actions, such as operating an electric drill or a chisel or piloting a jet fighter. Work habits refer to collections of behaviors that are more motivational in character. According to Primoff and Eyde (1988), one of the advantages of JEM over more narrow task analytic approaches to job analysis is the

Table 3.1 Examples of Job Elements

Job	*Element or Subelement*
Office Manager	Ability to gain conformance Ability to apply procedures Ability to meet deadlines
Police Officer	Have good physical coordination No fear of firearms Ability to recall facts
Electrician	Understanding of theory and instruments Understand ammeter, ohmmeter, voltmeter Knowledge of shop math

SOURCE: Adapted from Primoff, E. S., & Eyde, L. D. (1988). Job element analysis. In S. Gael (Ed.), *The job analysis handbook for business, industry, and government* (Vol. II, pp. 807–824). New York: Wiley. Reprinted by permission of John Wiley & Sons, Inc.

use of work habits as elements. Work habits used as elements might include such items as willingness to take on extra work or willingness to make sure that the work is done perfectly, without error. Table 3.1 contains sample elements and subelements for several jobs.

Steps in the JEM

Here are the steps:

1. Gather elements from subject matter experts
2. Have the experts rate each element on four scales
   a. B
   b. S
   c. T
   d. P
3. Derive scale values from the expert ratings
4. Share derived ratings with experts
   a. TV
   b. IT
   c. TR
5. Use results in your application (for example, developing tests)

Each step is explained in detail next.

GATHERING INFORMATION FOR JEM

JEM is usually conducted by a professional analyst, who serves as the project leader, and a team of six subject matter experts (SMEs), who are usually incumbents and supervisors. There are typically two sessions that take 3 to 5 hours each. During the first session, SMEs brainstorm and rate a list of elements that the analyst compiles. The product of the session will be a list of job elements and ratings of them. The analyst will then retire to analyze the ratings and compile the results. After some work, the analyst will return to the SMEs for the second session, in which the results of the first session will be put to some particular purpose, such as developing a test, performance measure, or training program.

In the first session, the analyst will encourage the SMEs to be exhaustive in their list of elements. When the SMEs begin to tire, the analyst will ask such questions as:

- What else might a worker show that would prove he or she is superior?
- If you had to pick out one person to get a special bonus for outstanding work, what might you look for?
- What might make you want to fire someone?
- If a worker is weak, what might cause trouble? (Primoff & Eyde, 1988, p. 809)

When all of the elements have been listed, the analyst asks the SMEs to provide subelements. Subelements are specific behavioral examples that illustrate the meaning of the element. For example, in Table 3.1, under the electrician job, an example element was "Understanding of theory and instruments." This was illustrated and partially defined by the subelements "Understand ammeter, ohmmeter, voltmeter" and "Knowledge of shop math."

RATING SCALES

At this point, the analyst has compiled a series of statements (elements) that detail what a worker needs in order to do the job. The worker traits (knowledge, skills, abilities, and other characteristics) are behaviorally defined in terms that job experts understand. The next step in the job analysis is to collect ratings from the analysts on a series of four rating scales. The rating scales used by JEM are Barely Acceptable (B), Superior (S), Trouble Likely If Not Considered (T), and Practical (P). All scales are rated with a three-category response. The SME provides a 0 if the scale has some minimal value, a check (✓) if the scale applies somewhat, and a plus sign (+) if the item is highly applicable.

Barely Acceptable (B)

The rating for the B scale requires a judgment as to whether barely acceptable workers must possess an element to do the job. Barely acceptable workers are those who are just scraping by. If they were any worse, they would not be qualified to do the job. Barely acceptable workers must possess the most basic of skills; otherwise they would not be acceptable. If almost none of the barely acceptable workers have the element, the SME would give a 0. If some barely acceptable workers have the element, it would receive a ✓, and if all have it, it would receive a +. If we consider the element "breathing" for most jobs, all barely acceptable workers would have this element (otherwise they would probably not be able to work), so SMEs would assign a + to this element.

Superior (S)

The rating for the S scale asks SMEs to describe how useful the element is for distinguishing the superior worker (0 is *not useful,* ✓ is *valuable,* and + is *very important*). It might be helpful to think about things that might earn a worker some kind of award from his or her employer, for example. The point is not merely that the superior workers possess the characteristic but that, in addition, the characteristic distinguishes the superior worker from the other workers. For example, superior workers all breathe, but breathing would not result in an award for superior work (the SMEs would assign a 0 to this element). A police officer might receive an award for bravery, for example, when the officer risked his or her own life to save the life of a person in a burning building. If so, bravery (or conduct above and beyond the call of duty) might get a + for this element.

Trouble Likely If Not Considered (T)

The rating for the T scale asks SMEs to describe whether trouble is likely if the element is not included in an examination or screen for new hires (0 is *OK to ignore,* ✓ is *some trouble,* and + is *much trouble).* For example, breathing is safe to ignore. Although there most certainly would be problems on the job if one didn't breathe, this can be safely ignored because all the applicants can be assumed to breathe. It is not something we would test for. On the other hand, we would expect a great deal of trouble if a brain surgeon were unable to use surgical instruments such as scalpels and clamps deftly (causing SMEs to select + for this element). For another example, we might expect trouble for visually impaired operators of heavy equipment such as buses and aircraft.

Practical (P)

The rating for the P scale asks SMEs whether job applicants are likely to possess the element. If we select for the element, how many of our job openings can we fill? (0 is *almost no openings,* ✓ is *some openings,* and + is *all openings.)* Again, if we consider the element *breathing,* we would expect to fill all openings after requiring it and screening for it. On the other hand, if we require fluency in two foreign languages for grocery clerks, we are unlikely to fill any positions (at least in the United States).

DERIVED SCALES

The analyst will then take the SME responses and prepare them for the second session. The SME responses to the four scales are analyzed and combined in various ways (some rather complex) to make them more useful for human resources applications. Table 3.2 shows the results of one such analysis.

The first four columns refer to the scales completed by the SMEs, that is, Barely Acceptable, Superior, Trouble Likely, and Practical. The numbers in the columns are percentages of the maximum possible scale scores. For example, with six SMEs, the maximum possible points would be 12 (where 0 = 0, ✓ = 1, and + = 2). If the sum of the SME points were 6, the percentage would be 50.

Total Value (TV)

The first derived scale is total value (TV). *Total value* refers to the value of the element in "differentiating abilities of applicants for a job" (Primoff & Eyde, 1988, p. 812). The scale is defined as $TV = (S—B–P) + (SP + T)$, which is not a blindingly obvious formula. So let's take it a little at a time to try to make sense of it. The first part of TV is $(S—B–P)$. The first term basically says, "Let's select employees using elements that are both (1) useful in spotting superior workers and (2) not found among most of the people in our workforce." The second part of the equation $(SP + T)$ also contains S and P, as did the first. This time, however, they are being multiplied rather than subtracted. The reason that S and P are multiplied in this part of the equation is so that if we cannot fill any of the positions if we select on the element $P = 0$, then the product SP will be zero, so the high standing on S will be discounted. This means that the total sum will be reduced so that we are less likely to select for something that we cannot find. We then add the value for T (Trouble Likely) because we want to select for troublesome elements if we can. So, taken as a whole, TV says something like this, "Let's select for elements that pick workers who will prove superior and reject workers who will prove to be problems. But let's not select for the elements if they are too common or too uncommon among workers." The TV scores are calculated as sums of points and then transformed so that their maximum value is 150. TV values greater than 100 are thought to be significant and are called *elements* in the JEM results.

Item Index (IT)

Item index (IT) refers to the extent to which a subelement is important in the content of a test. IT is computed by $IT = SP + T$, which is the second part

Table 3.2 Partial JEM Results for a Police Officer

Element	*B*	*S*	*T*	*P*	*TV*	*IT*	*TR*
Have good physical coordination (S)	60	63	79	92	55	65	46
Have no major physical incapacity (RS)	81	44	96	94	23	59	33
Ability to engage in weaponless physical contact (S)	68	68	80	87	55	66	49
No fear of firearms (S)	73	49	81	90	27	56	33
Ability to compare signatures	39	58	27	50	29	29	50
Ability to recover from glare of oncoming lights (S)	74	43	71	89	15	50	25
Have sufficient height to see over roofs of cars (SC)	92	30	71	95	14	43	6
Ability to work outdoors in bad weather for long periods (S)	72	53	67	92	26	54	29
No unusual vocal characteristics (lisp, high pitched)	66	37	62	94	4	44	19
Ability to change a car tire (SC)	94	23	57	95	32	33	4
Ability to determine reasonable grounds for arrest (TS)	60	89	48	44	56	42	88
Ability to function while in physical danger (E)	58	94	90	86	101	84	76
Have honesty (RS)	76	85	98	95	86	86	58
Possess good judgment (E)	46	96	86	93	111	88	75
Have good leadership ability (TS), (S)	25	92	53	71	90	62	86

SOURCE: Adapted from Primoff, E. S., & Eyde, L. D. (1988). Job element analysis. In S. Gael (Ed.), *The job analysis handbook for business, industry and government* (Vol. II, pp. 807–824). New York: Wiley. Reprinted by permission of John Wiley & Sons, Inc.

NOTE: In column heads, B, S, T and P are the four rating scales: B = Barely Acceptable, S = Superior, T = Trouble Likely If Not Considered; P = Practical, TV = Total Value; IT = Item Index; TR = Training Value

In parentheses, E = Element, S = Significant Subelement, RS = Rankable Screenout, TS = Training Subelement, SC = Screenout. You cannot obtain the tabled values of TV, IT, and TR in this table from the tabled values of B, S, T, and P because the resulting columns (TV, and so on) are rescaled after they are calculated. Items in the column headings are defined in the text.

of the TV computation. The numbers in the IT column are also percentages of the maximum possible score. Subelements with IT values greater than 50 can be used to rank applicants.

Training Value (TR)

Training value (TR) refers to the value of the element in training, amazingly enough. TR is computed by $TR = S + T + SP'—B$, where P' is the reverse of P, so that if all openings can be filled by applicants, then $P = 0$. This basically says that we would like to train people on skills that superior workers have and that will prove troublesome if absent ($S + T$). However, we only need to train employees on those skills that are not readily available in the labor pool ($SP'—B$).

ASSIGNING ELEMENTS TO CATEGORIES

Elements or subelements are determined by their profiles of scores as shown in Table 3.3.

During the second session, the analyst will share the results of the first session with the SMEs, as is shown in Table 3.3. The SMEs will make use of the information in such activities as designing tests. JEM is particularly useful in developing work sample tests for selection. For example, one screenout item in

Table 3.3 Categories of JEM Elements and Subelements

Category	*Description*
E	Element is marked when the TV is 100 or greater. (If E is marked, no other letter is marked.)
S	Significant subelement is marked when IT is 50 or greater.
TS	Training Subelement is marked when TR is 75 or greater.
SC	Screenout (minimum requirement) is marked if B and P are both at least 75 and T is 50 or greater.
RS	Rankable Screenout is marked if a subelement meets both the values for S (Significant subelement) and SC (Screenout). RS means that the subelement has a minimum value needed for the job, but above that level can also be used to rank job applicants.

SOURCE: Adapted from Primoff, E. S., & Eyde, L. D. (1988). Job element analysis. In S. Gael (Ed.), *The job analysis handbook for business, industry, and government* (Vol. II, pp. 807–824). New York: Wiley. Reprinted by permission of John Wiley & Sons, Inc.

Table 3.2 is "Have sufficient height to see over roofs of cars." It would be a simple matter to take a person into a parking lot and see whether he or she can see over the roofs of most cars. Of course, it might be simpler still to determine what minimum height is needed to see over the roofs of cars and then use a yardstick to measure job applicants for that minimum. (This element would cause some controversy in practice because it constitutes a height requirement that will exclude a disproportionate number of women. Is this item important enough to include in an expensive testing process?) For another example, another screenout item is "Ability to change a car tire," and this item might make a reasonable work sample test. Unfortunately, some elements do not easily result in work sample tests. Consider the rankable screenout item "Have honesty." It is not immediately clear to us how this should be tested. Should we check for lies on an application blank? Should we leave a wallet in the room with the applicants to see if they report it or pocket it? Should we ask them questions taken from social desirability scales, such as "Before voting, do you carefully check on all the candidates?" Answering "Always" to this question may indicate that a person is more interested in creating a favorable impression than in being honest.

JEM also provides for checks on the job analysis through the development of products that were the impetus for the analysis. For example, a test may be developed. If the test is not working properly, then the problematic aspect of the test may lead to another look at the job. For example, in a test of electricians, Primoff and Eyde (1988) noted that some electricians who were clearly not qualified were passing a portion of the exam. This caused the analysts to revisit the job, where they found that the better electricians could use and maintain specific electrical equipment. The test was modified to include this equipment, and the problem was solved. The unqualified electricians no longer passed the test. JEM can also be used to choose tests developed outside the current job and job analysis. We turn to this next.

RESEARCH ON JEM: THE J-COEFFICIENT

The J-coefficient (job coefficient) was developed by Primoff in the 1950s. Perhaps because most of Primoff's writings were published by the U.S. government rather than in the typical academic journals, his ideas were never widely adopted. However, his intuitions about the way job elements and tests are related turn out to have an elegant mathematical basis that few scholars have pursued. We present the basic ideas without the elegant mathematics (but we do, of course, provide references for those with a thirst for a deeper understanding of the issues).

Overall job performance represents a value to the organization that results from the incumbent's performance over some period of time on specific tasks. In the case of a police officer, for example, overall job performance might result from making arrests, driving safely, being a mentor to a new, junior officer, addressing elementary school children as part of a community relations program, and so forth. Alternatively, we might think of overall job performance as resulting from a series of job elements such as those collected during JEM (for example, recovering from the glare of oncoming lights, functioning well while in physical danger, behaving honestly). In other words, the job elements cause overall job performance. Some job elements may be more important than others, and the more important elements should be more highly correlated with overall job performance in a population of workers. If we were to correlate auto mechanics' overall job performance with various elements, we would expect to find that mechanical aptitude showed a higher correlation than did ability to function while in physical danger, for example.

In traditional test validation, some measure of overall job performance is correlated with a test (the resulting correlation is often called a *validity coefficient;* we cover correlations in Chapter 9, doing a job analysis). For example, supervisory ratings of overall job performance by mechanics might be correlated with test scores on a mechanical aptitude test. We would expect to see that better mechanics as indicated by their supervisors would also have the higher test scores. The J-coefficient is an estimate of the validity coefficient that would result if such a validation study were conducted. However, the J-coefficient is derived in part from human judgments rather than empirical comparisons of test scores and overall job performance.

To compute a J-coefficient, we need three pieces of information: (1) the correlations of job elements with overall job performance, (2) the correlations of tests with the job elements, and (3) the correlations of the job elements among themselves. Primoff advocated using SMEs to provide estimates of the correlations of the job elements with overall performance for any given job. The other values (correlations of tests with elements and of elements with elements) were to be developed over years of research and compiled into tables in which the accuracy would increase as evidence mounted across people and jobs. A computational example of a J-coefficient is shown in Trattner (1982). Given information about several tests, one can compute J-coefficients for each test and then choose the test with the largest coefficient.

Although Primoff suggested the use of judgment for element-job performance information and a more empirical approach for test-element relations, it is clearly possible to use humans to estimate test-element correlations and to compute empirical estimates of element-performance relations. Hamilton and Dickinson (1987) compared several different methods for generating the information needed for J-coefficients and found that several different methods provided comparable, consistent estimates of J-coefficients. Furthermore, they compared the J-coefficients to validity coefficients computed on the same sample and found close agreement between the two estimates, thus suggesting that human judges can provide data useful for predicting the validity of tests when traditional validation studies are not feasible.

REMARKS ON JEM

JEM is admittedly circular (and proudly so, we might add). For example, in a job element analysis, a sample ability is "Ability to disassemble an office desk." Note that such an ability is defined to be whatever is needed to complete the task successfully. There is no necessary reference to some other knowledge or ability that might explain task performance, such as knowledge of mechanical principles, knowledge of the use of tools, spatial reasoning, and so forth. JEM does not deny the existence of knowledge, skills, abilities, and other characteristics (and sometimes incorporates more abstract elements). However, rather than talking about such basic aspects of tasks, JEM often refers to broader and narrower collections of job-oriented behaviors. As Primoff and Eyde (1988) noted, "Tests and other products are *not* inferred from the job analysis, but *incorporate* the work example definitions of the subelements" (p. 815, italics in the original).

We find this to be a powerful argument when JEM is used to develop tests that are essentially work samples. Part of the reason for avoiding basic abilities such as perceptual speed or analytical reasoning is most likely the strong behaviorist tradition in psychology in the United States that lasted almost from the beginning of psychology until the 1970s. As much as humanly possible, behaviorists avoided talking about mental states and instead focused on observable behavior. Thus, the focus on work behavior as a worker-oriented approach is very satisfying to a behaviorist. In more recent years, psychology has become focused on cognitive process and states, turning away from the behaviorists' denial of the usefulness of mental states.

However, the argument that traits are not inferred is less compelling when JEM is used to select tests that have been constructed for other purposes. When picking tests off the shelf, JEM used a standard set of abilities and tests that had tabled relational values. (The tabled values indicate how closely tests and work elements are associated with one another.) Such a scheme does require job analysts to infer the degree to which such abstract abilities as perceptual speed and verbal reasoning are required by the job. Also, the emphasis on observable behaviors might lead to ignoring efficient, valid tests that could enhance the effectiveness of employee selection.

Let us briefly mention two other problems with JEM. First, there has been no solid evidence to show that the complex rating formulas are always necessary. Second, a heavy reliance on SME input from start to finish can lead to screening tools that can get you into some legal hot water. The height requirement we mentioned for the job of police officer is an example.

Despite its problems, JEM has had a huge impact on job analysis. Aspects of this approach have found their way into many other methods. And the terms *knowledge, skills, abilities,* and *other characteristics* have become part of the lingo of job analysts everywhere.

Position Analysis Questionnaire

DEVELOPMENT AND STRUCTURE OF THE PAQ

The PAQ was developed in the 1960s by Ernest McCormick (as well as his colleagues at Purdue University). It was designed around the well-known behaviorist formula S-O-R, where the organism (O) receives a stimulus (S) and makes a response (R). But the PAQ also notes that the environment and social setting play a role in job performance. Unlike JEM, the PAQ was designed so that the same elements apply to all jobs. Again, the term *element* has a different meaning across the two techniques.

Before 2004, the PAQ consisted of 194 items or elements. Of these, the first 187 concern either a human attribute (for example, color perception) or an aspect of the job requiring accommodation by the human (for example, the job makes use of written information, the jobholder experiences vibration). The last seven items (188–194) concern compensation (pay) for the job and are not considered here. The items are collected into six major divisions, which are listed in Table 3.4. Information input, for example, concerns what type of information the jobholder gets, and where and how he or she gets it. The major divisions are further divided into subdivisions called *sections* and *subsections.* Each section or subsection is composed of related items. Sample subdivisions and items are also listed in Table 3.4. In 2004, the PAQ was supplemented by job analysis questions used in U.S. Social Security disability determinations; new job analysis questions added by the August 23, 2004, amendment to the Fair Labor Standards Act (FLSA; the first major change since 1949); analysis questions long-believed to be required, such as "ability to sit/stand/shuffle"; education requirements; and certain stress-related questions. Exactly 300 items are now used.

The job analyst considers each item relative to the job under consideration and decides whether the item applies to the job. If the item does apply, then the analyst rates the job on the item. Although the PAQ is named for the term *position,* it is typically used to analyze the *job* as we have defined it. That is, the PAQ is usually used to analyze a group of related positions that are similar enough to be called a job and given a single title. (You have won our undying gratitude if you remembered this.) The analyst then records for each item his or her judgment about the item with regard to a rating scale developed for the PAQ. There are six different rating scales used in the PAQ. Only one rating scale applies to any given item. Each rating scale is illustrated in Table 3.5 along with sample items.

The PAQ manual notes that specially trained analysts, managers, and even incumbents can complete the PAQ. However, in most cases specially trained analysts should be used. We recommend that incumbents should not, if possible, complete the PAQ because it requires a high level of reading comprehension and many rather abstract judgments. Also, many of the PAQ scales will not

Table 3.4 Structure of the Position Analysis Questionnaire

Major Division	*Subdivision*	*Illustrative Job Element*
Information Input	Sources of job information Discrimination and perceptual activities	Use of written materials Estimating speed of moving objects
Mediation (Mental) Processes	Decision making and reasoning Information processing Use of stored information	Reasoning in problem solving Encoding/decoding Using mathematics
Work Output	Use of physical devices Integrative manual activities General body activities Manipulation/ coordination activities	Use of keyboard devices Handling objects/ materials Climbing Hand-arm manipulation
Interpersonal Activities	Communications Interpersonal relationships Personal contact Supervision and coordination	Instruction Serving/catering Personal contact with public customers Level of supervision received
Work Situation and Job Context	Physical working conditions Psychological and sociological aspects	Low temperature Civic obligations
Miscellaneous Aspects	Work schedule, method of pay, and apparel Job demands Responsibility	Irregular hours Specified (controlled) work pace Responsibility for safety of others

SOURCE: Adapted from McCormick, E. J., Jeanneret, P. R., & Mecham, R. C. (1989). *Position analysis questionnaire.* Logan, UT: PAQ Services, Inc. Reproduced by permission of PAQ Services Inc.

Table 3.5 Sample PAQ Scales and Items

Item Type	*Sample Item*
Extent of Use (U)	17. Touch (pressure, pain, temperature, moisture, etc.) (information input) N = Does not apply; 1 = Nominal/very infrequent; 2 = Occasional; 3 = Moderate; 4 = Considerable; 5 = Very substantial
Importance to the Job (I)	39. Analyzing information or data (for the purpose of identifying underlying principles or facts by breaking down information into component parts, for example, interpreting financial reports, diagnosing mechanical disorders or medical symptoms, etc.) (mental processes) 113. Executives/officials (corporation vice-presidents, government administrators, plant superintendents, etc.) (relationships with other persons) N = Does not apply; 1 = Very minor; 2 = Low; 3 = Average; 4 = High; 5 = Extreme
Special Codes (S)	46. Education (indicate using the code below, the level of knowledge typically acquired through formal education that is required to perform this job. Do not consider the type of knowledge typically acquired in technical or vocational school—see item 48) (mental processes) N = Does not apply; 1 = Less than that required for completion of high school curriculum; 2 = Level obtained by completion of high school curriculum; 3 = Level obtained by some college work; 4 = Level obtained by completion of usual college curriculum; 5 = Level obtained by completion of advanced curriculum (such as graduate school, medical school, law school, etc.)
Amount of Time (T)	89. Standing (do not include walking) (work output) N = Does not apply (or is very incidental); 1 = Under 1/10 of the time; 2 = Between 1/10 and 1/3 of the time; 3 = Between 1/3 and 2/3 of the time; 4 = Over 2/3 of the time; 5 = Almost continually
Possibility of Occurrence (P)	145. Temporary disability (temporary injuries or illnesses which prevent the worker from performing the job from one full day up to extended periods of time but which do not result in permanent disability or impairment) (job context) N = No possibility; 1 = Very limited; 2 = Limited; 3 = Moderate; 4 = Fairly high; 5 = High
Applicability (A)	154. Business suit or dress (expected to wear presentable clothing such as tie and jacket, street dress, etc., as customary in offices, stores, etc.) (other job characteristics) N = Does not apply; 1 = Does apply

SOURCE: Adapted from McCormick, E. J., Jeanneret, P. R., & Mecham, R. C. (1989). *Position analysis questionnaire.* Logan, UT: PAQ Services, Inc. Reproduced by permission of PAQ Services Inc.

apply for any given job, and this may be difficult for an incumbent to accept. Incumbents should usually not fill out the PAQ when job analysis is to be used for determining compensation.

In completing the PAQ, the trained analyst ordinarily first observes and then interviews several incumbents who are performing the job. Observing the job is very useful in understanding the job context (noise, vibration, heat, and so on). It is also a useful point of departure for the analyst to note what is not obvious from watching the job. For example, a person operating a machine may know what to do from looking at a dial, from a timed duration, or simply from listening to the sounds a machine is making. It may not be obvious to an observer just what cues the incumbent is using. After observing the job, the analyst interviews one jobholder after another to complete the items in the PAQ. In general, the analyst talks to the jobholder about the PAQ item and its relevance to the job. For most of the items, however, the job analyst actually decides on the appropriate rating. For a few items, such as time spent, the analyst may ask the jobholder for a rating.

PAQ RESULTS

The PAQ is scored by computer. The computer printout lists dimension scores and overall scores for the major PAQ divisions. In addition, the computer prints estimates of aptitude test scores, estimates of job evaluation points to be used for setting salaries, and FLSA analyses, the computer's analysis on whether or not the job is covered by the Fair Labor Standards Act (see Chapter 7 for a description of the FLSA).

The PAQ also provides more detailed information about each item (element) in the survey that shows how the current job compares to other jobs contained in the PAQ database. The PAQ database has a large number of jobs cutting across the whole economy. In general, the numbers show how much of the attribute the job requires relative to other jobs.

USES OF THE PAQ

The PAQ was designed to meet two primary objectives. The first was to develop a standardized approach to identifying the person requirements of jobs, thus eliminating the need for costly test validation studies for each job (at least this was the intent). The second purpose was to help organizations with job evaluation for compensation. Early research on the PAQ, therefore, concerned selection and job evaluation. However, other uses for the instrument were adopted, and the record of research has grown quite large. Today, a major use of the PAQ is for determining disability; it is used by many long-term disability insurance carriers.

RELIABILITY AND VALIDITY

Several studies have examined the reliability of PAQ ratings, and the results have been mixed (see Jones, Main, Butler, & Johnson, 1982; McCormick & Jeanneret, 1988; Smith & Hakel, 1979). Agreement among judges has typically been highest when the comparison is of scores across items for the same job and lowest when the comparison is across the same items between jobs. That is, judges tend to agree with one another when both are filling out the PAQ on the same job and we compare scores across items. Note that this does not tell us about how well the PAQ can distinguish among jobs. For that, we have to analyze multiple jobs. When we examine agreement across jobs, we find that the agreement is not as good. Studies have also examined the rate-rerate reliability of the PAQ. The resulting estimates are in the high .70s and .80s (McCormick & Jeanneret, 1988), which is satisfactory. McCormick and Jeanneret (1988) also noted that such stability estimates were obtained from trained job analysts as well as job incumbents and supervisors, although the incumbents and supervisors tend to give higher ratings. However, the same concerns about the meaning of reliability estimates (within versus between jobs) between judges also apply to rate-rerate estimates.

One line of research related to the validity of the PAQ concerns the relation of PAQ scale scores to salary data across jobs. Recall that one of the main purposes of the PAQ was to determine compensation. Differences in job requirements should be related to differences in pay, so that more demanding jobs should be more highly paid. Numerous studies of the PAQ have shown that scores derived from the PAQ predict well salary data across jobs and occupations, that is, salary data aggregated across positions (for example, McCormick, Jeanneret, & Mecham, 1972). Such results support the validity of the PAQ.

The PAQ was also intended to be useful in personnel selection. Research has shown that PAQ scales were related to incumbent mean scores on the General Aptitude Test Battery (GATB; U.S. Department of Labor, 1967) across 163 jobs (McCormick et al., 1972). Furthermore, the PAQ was able to show differences in validity, that is, the test-criterion correlation based on the job requirements. For example, when the PAQ's estimates of the need for cognitive ability in jobs increased, the validity of tests of cognitive ability increased (Gutenberg, Arvey, Osburn, & Jeanneret, 1983).

RESEARCH ON THE PAQ: COMMON KNOWLEDGE EFFECTS

The study we mentioned earlier by Smith and Hakel (1979) generated a lot of interest in the research community. What they did was to collect PAQ ratings on 25 jobs from five groups of people, namely, incumbents, supervisors, job analysts, undergraduate students given only a job title, and undergraduate students given a job title plus additional information about the nature of the job. In this study, students given only a job title were almost as reliable as professional job analysts. More remarkable were the correlations among the PAQ ratings when averaged within each group. All of the groups produced PAQ ratings that on average correlated in the .90s with the rest of the groups' averages, which indicates that the resulting PAQ profiles were virtually indistinguishable. This result generated a lot of interest because if students armed solely with job titles can produce the same PAQ profiles as professional analysts, then (among other things) the job security of the analysts is in question. How could this be? Does the PAQ only measure shared job stereotypes or do most people actually have a pretty good idea of the abilities needed to tackle lots of jobs?

Further evidence that analysts could produce reliable PAQ ratings from reduced information (that is, something less than observing and interviewing incumbents) was provided by Jones et al. (1982). Perhaps part of the problem is that the PAQ is not very sensitive to the amount of information available to the analyst; that is, it measures only large differences among jobs. If so, the PAQ could show the difference between, say, a professor of mathematics and a jet engine mechanic, but not between a professor of mathematics and a professor of geology. Indirect evidence in support of this position was given by Surette, Aamodt, and Johnson (1990), who asked students to analyze the job of college resident assistant.

Others, however, were quick to point out that perhaps the results in Smith and Hakel (1979) and Jones et al. (1982) were in some sense misleading. One thrust of the rebuttal concerns the DNA, or "does not apply," items found in the PAQ. If we score such items "zero" and include them in the reliability analysis, we find that the reliabilities are larger than if we exclude such items from the analysis. In other words, people who are not very familiar with the job may still know that some elements do not apply to the job. For example, we can guess that a taste tester makes little use of written sources of information on the job. On the other hand, most professors do make use of written information, but they do not use long-handled tools (except, perhaps, when disciplining unruly students). Evidence consistent with this position was provided by Harvey and Hayes (1986) and by DeNisi, Cornelius, and Blencoe (1987).

Others set about investigating the agreement among items that *do* apply in the PAQ (Cornelius, DeNisi, & Blencoe, 1984). It turns out that people given little job information do not agree well with one another or with experts about the degree to which the items that do apply are important to the job. For example, lay people may agree that a patrol officer makes use of written information, but may not agree about how frequently such information is used. Friedman and Harvey (1986) also found that more information given to analysts produced better agreement.

What are we to make of all this? First, people do have a general knowledge of the gross outlines of occupations that allows them to tell that some items are not likely to apply to a given job. The resulting PAQ profiles across jobs show more accuracy than one would expect, primarily because of the DNA items. On the other hand, to get high-quality PAQ profiles, the person who fills out the PAQ needs to be very familiar with the job and trained in completing the PAQ. In general, students armed solely with a job title are not likely to provide very accurate ratings.

RECENT PAQ DEVELOPMENTS

PAQ Services changed owners in 2004. There are several new developments as a result. PAQ Services is now managing what it calls the *enhanced Dictionary of Occupational Titles* (eDOT), which is intended to replace the Department of Labor's *DOT.* PAQ also manages the eDOT Skills Project, which updates the data in the eDOT, including adding new titles, such as Web designer, and archiving old titles that no longer exist in today's economy.

The PAQ has also incorporated new items of various sorts. Some new items concern regulations regarding the assessment of exemption status under the Fair Labor Standards Act. Historically, PAQ has provided an FLSA exemption prediction with all job analyses. To provide accurate status estimates under the new (2004) FLSA rules, PAQ incorporated FLSA items directly from the regulations. Other new item types include items related to professional and managerial work, the addition of Social Security Disability Assessment items, and other job analysis items to meet a wider variety of human resource (HR) needs.

PAQ Services provides support to instructors through products and services that can be used in the classroom, including free PAQ materials, scoring, reports, job analysis software, and HR courses. More information may be obtained on the PAQ Web site: www.paq.com.

REMARKS ON THE PAQ

The PAQ has been used extensively, often to solve problems related to personnel selection and job evaluation. As mentioned earlier, despite the PAQ's popularity and broad use, we do not recommend its completion by job incumbents who are not highly educated because the reading level of the PAQ is high, and many judgments called for are hard to make. We would also avoid having incumbents and supervisors complete the PAQ when it is used for determining compensation because both groups tend to provide higher ratings and mark more items as applying than do professional analysts. The PAQ is often not very informative about managerial jobs. We are pleased by several recent developments in the PAQ, especially with efforts to use electronic means to update a national database of job information.

The PAQ has many positive qualities to recommend it. It uses a common set of elements for all jobs. The common elements help make it useful for job evaluation and for forming job clusters or families. The PAQ is helpful in identifying knowledge, skills, and abilities and in defending the job-relatedness of tests. Also, it is an off-the-shelf method that is relatively quick and inexpensive to use. The PAQ is the first of several methods for estimating trait requirements for jobs; we briefly describe three of these next.

Other Trait-Based Worker-Oriented Measures

There are many other worker-oriented job analysis methods that are based on sets of human skills and abilities. Rather than describe each of those in detail, we briefly sketch a few selected systems. The interested reader can pursue any or all in more detail as the need arises and can explore other methods in addition to the ones described here.

THRESHOLD TRAITS ANALYSIS SYSTEM

The Threshold Traits Analysis System was developed in 1970 by Felix Lopez to provide a theoretically coherent, trait-oriented, multipurpose, and legally defensible method of job analysis (Lopez, 1988). The entire TTAS contains several different pieces. Some pieces are designed for describing traits for selection, some are designed for training, and some are designed for job description (although a TTAS can be used for other purposes as well, including job evaluation). However, the heart of the system is the threshold traits analysis (TTA), which is based on a standard set of 33 traits. TTAS traits are broadly classed into two sections, "can do" and "will do." The "can do" traits are described as abilities and contain the physical, mental, and learned traits. Under the physical area, for example, is the job function "physical exertion." Physical exertion includes the traits "strength" and "stamina." Strength is described as the ability to lift, push, or pull objects, and stamina is described as the ability to expend physical energy for long periods. For a second example, under the mental area a job function is "information processing." One of the information processing traits is "comprehension," which is described as the ability to understand spoken and written ideas.

The "will do" traits are described as attitudes and contain the motivational and social traits. Examples of motivational traits include "adaptability to change," "adaptability to repetition," and "dependability." Examples of social traits include "tolerance," "influence," and "cooperation." The 33 traits and their examples are designed for communication with analysts and users of the job analysis products. The traits can be further subdivided if necessary and lists of synonymous traits are provided in the manuals describing the system (Lopez, 1986).

ABILITY REQUIREMENTS SCALES

The ability requirements approach was developed by Ed Fleishman and his colleagues (for example, Fleishman, 1982; Fleishman & Mumford, 1988;

Fleishman & Quaintance, 1984). A comprehensive description of each ability and tests for each are described in Fleishman and Reilly (1992). A sample of these abilities is shown in Table 3.6. The Ability Requirements Scales are used to evaluate or judge the degree to which each of the generic human abilities is required by the job. Because each of these abilities is linked to one or more tests, results of the ARS job analysis may be used for selection. The generic nature of these abilities also lets us build job families, which are clusters of jobs that are similar in their required abilities.

OCCUPATIONAL REINFORCER PATTERN

The theory behind this method is based on how individuals differ in their needs (Borgen, 1988). For example, some people need more recognition than others do. Some people are not happy working alone, but others are. Some prefer to work in formal settings, whereas others prefer to work in casual settings, and so forth. The Occupational Reinforcer Pattern is an attempt to represent the

Table 3.6 Examples of Generic Human Abilities

Ability	*Description*
Cognitive Abilities	
Oral comprehension	Understand spoken words
Mathematical reasoning	Reason with mathematical symbols
Speed of closure	Combine bits into meaningful pattern
Spatial orientation	Tell where you are in relation to an object
Psychomotor Abilities	
Control precision	Operate a vehicle
Multilimb coordination	Coordinate movements of two or more limbs
Finger dexterity	Make skilled movements of the fingers
Speed-of-limb movement	Move limbs quickly
Physical Abilities	
Static strength	Exhibit push or pull strength
Dynamic flexibility	Repeatedly bend, stretch, and twist
Gross body equilibrium	Demonstrate balance
Stamina	Continue working over time
Sensory/Perceptual Abilities	
Night vision	See in the dark
Hearing sensitivity	Hear loudness and pitch
Speech recognition	Understand speech
Speech clarity	Speak clearly

ways in which jobs provide the things that people want or need. Thus, the ORP is intended to be useful for vocational guidance. There are associated tests of needs for individuals that can be used to suggest occupations that appear to be appropriate for an individual based on the similarity of the needs of the person to the rewards provided by the job. The traits used in ORP are shown in Table 3.7.

Table 3.7 Examples of Occupational Reinforcers

Reinforcer	*Description*
1. Ability utilization	Use your abilities
2. Activity	Keep busy all the time
3. Authority	Tell people what to do
4. Compensation	Fair pay
5. Creativity	Try out own ideas
6. Moral values	Avoid conflict between work and self
7. Security	Have steady employment
8. Social status	Job with prestige
9. Variety	Work changes frequently
10. Autonomy	Plan work with little supervision

METHODS WITH SUBSTANTIAL ATTENTION TO EQUIPMENT

We have not yet described worker-oriented approaches that emphasize equipment. Two such approaches are AET (for three long German words; Rohmert, 1988) and the Job Components Inventory (Banks, 1988).

AET

The AET (okay, you asked for it, *Arbeitwissenschaftliches Erhebungsverfahren zur Tätigkeitsanalyse*—as promised, the translation is "ergonomic task analysis data collection procedure") comes from an ergonomics perspective, which attempts to minimize human stress and strain while maximizing performance quality and quantity. The AET pays particular attention to the equipment used to complete the work and to the working conditions or environment. The AET is often used in redesigning work to make it less stressful to the workers.

Ergonomics is about designing things for human use. This is an exciting and rewarding field if you like doing things that have a beneficial impact on other people's lives. Just because someone is strong doesn't mean that he or she should spend all day lifting wheels from the ground onto automobile axles.

It might be possible to build a ramp so that the wheel rolls to the axle and saves the worker from repetitive back strain. Ergonomic design ranges from the simple to the complex—from hand tools such as screwdrivers to computer interfaces that can be programmed to fly a jet from Denver to Atlanta without further human input. It is also involved whenever we want to make accommodations for disabilities. We may change the job to eliminate a task that is difficult for an individual, or we may change the way in which the task is accomplished by providing a work aid or tools of some sort. If the job occasionally involves driving a car, for example, we might move that task to another person so that an otherwise qualified person could do the job. Or we might provide a magnifying glass and bright light for a worker who has poor vision.

Job Components Inventory

The Job Components Inventory (Banks, 1988; Banks & Miller, 1984) was developed in Britain to describe a wide range of entry-level jobs. The descriptors were to be useful in vocational guidance and training so that young people could understand what the jobs actually were and how to prepare for them. One part of the JCI covers 220 tools and pieces of equipment. Some types and examples are tools for marking or drawing (scribes, dividers); tools for measuring length, angles, size, or levels (micrometer, protractor); and tools for holding or securing objects (clamp, tweezers). Although the JCI was designed primarily for vocational guidance purposes, because of its emphasis on tools, it can be used as part of job analysis for many training programs.

Cognitive Task Analysis

Cognitive task analysis is a worker-oriented approach that differs in several ways from the other methods we discuss in this chapter. Cognitive task analysis is the most recently developed of the methods described in this chapter. Applications began in the 1990s. Cognitive task analysis has its roots in cognitive psychology and cognitive science. Cognitive science is something of a blend of cognitive psychology, computer science, engineering, and philosophy that aims to understand the mind by producing models of mental activity. Cognitive scientists have become very interested in expertise. To study expertise, they typically take a task into the laboratory and have novices and experts complete it. They infer the mental activities that experts use to complete tasks, including strategies, processes, knowledge, and so forth. They then usually write computer programs that are intended to imitate what experts do.

Also unlike most of the other worker-oriented methods, cognitive task analysis does not refer to a specific set of traits or elements used to understand the human abilities required by work. Rather, cognitive task analysis refers to a collection of different approaches or methods that are related by their common goal of understanding the mental activities used by experts in completing the task being analyzed.

Cognitive task analysis usually begins with the completion of a work-oriented job analysis method that describes in detail the job's duties and tasks. From the list of tasks, some tasks are chosen for further study by means of cognitive task analysis. Cognitive task analysis is often very expensive, time consuming, and difficult to apply (Seamster, Redding, & Kaempf, 1997). Therefore, for applied work, some subset of tasks is chosen for further study using some cognitive task analysis methods that are appropriate and feasible. Cognitive task analysis provides information about the mental processes used to complete the job that are often omitted from both work-based methods and trait-oriented worker-based methods. For example, a pilot must navigate to fly successfully. A task from a pilot's task inventory might read "Determine current location." A trait-based worker-oriented method might list knowledge of maps and compasses, visual acuity, and visualization ability. However, none of these methods is likely to point out that there may be several different ways in which to determine one's current location and that the difference between novices and experts may lie chiefly in knowing when the different methods are most appropriate.

Seamster et al. (1997) presented a comparison between work-oriented task analysis and cognitive task analysis, which is summarized in Table 3.8.

Table 3.8 Comparison of Work-Oriented Task Analysis and Cognitive Task Analysis

Work-Oriented Task Analysis	*Cognitive Task Analysis*
Emphasizes behavior	Emphasizes cognition
Analyzes target performance	Analyzes expertise and learning
Evaluates knowledge for each task separately	Evaluates the interrelations among knowledge elements
Segments tasks according to behaviors required	Segments tasks according to cognitive skills required
Representational skills are not addressed	Representational skills are addressed
Describes only one way to perform	Accounts for individual differences

SOURCE: Adapted from Seamster, T. L., Redding, R. E., & Kaempf, G. L. (1997). *Applied cognitive task analysis in aviation.* Brookfield, VT: Ashgate. Reproduced by permission of Ashgate Publishing.

TYPES OF KNOWLEDGE AND SKILL

The descriptors used in cognitive task analysis often refer to knowledge and skill. Different authors slice the pie somewhat differently. However, some terms are commonly used, and these are described next. *Declarative knowledge* is factual knowledge, often of the type that can be spoken or declared. Declarative knowledge is knowledge of *what.* For example, the name of the current president of the United States is a bit of declarative knowledge that you most likely possess. If you have been reading this chapter, you now have the names of several worker-oriented job analysis methods on the tip of your tongue, and these names are also bits of declarative knowledge. *Procedural knowledge* is knowledge of *how.* Procedural knowledge implies steps, techniques, or procedures in general. For example, you probably know how to drive a car and how to ride a bicycle. You may know how to drive a car with a stick shift, and the sequence of steps involved in shifting gears (grab the gear shift, depress the clutch, foot off the gas, shift the gear, release the clutch while applying foot to gas, release the gear shift). If you drive a stick shift car, it is probably much easier for you to actually shift gears than it is for you to explain to someone else how to do it. Some authors describe *generative knowledge,* which allows you to figure out what to do in a new problem situation. You use generative knowledge when you arrive in an airport you have never seen before. Such knowledge will help you locate your baggage and transportation to your final destination. A final type of knowledge described here is *self-knowledge,* which refers to knowledge about what you do and do not know, and what you can and cannot do. You probably have a well-developed idea of the sorts of problems you can solve confidently and those you would not attempt. For example, most of us can make simple household repairs such as changing a light bulb, some of us can rebuild a car engine, and most of us would not willingly attempt surgery on ourselves.

Cognitive task analysis sometimes makes the distinction between knowledge and skill (Seamster et al., 1997). Seamster et al. (1997) described knowledge as referring to information possessed by the jobholder, whereas skill refers to a process that uses information (they talk about procedural skills rather than procedural knowledge). They defined several types of skill, including automated skills, representational skills, and decision-making skills.

Automated skills are mental processes that are fast and effortless. For most adult Americans, driving an automobile has become an automated skill. When you first begin to drive, it is a very difficult task, and changing the radio station while driving can be a real challenge. As driving becomes automated, however, virtually no effort is needed to keep the car in the proper lane at the proper speed, and one not only can change the radio station without much trouble but also can carry on a conversation or think about something totally unrelated to driving (but not, apparently, use a cell phone).

Representational skills imply the use of mental models, that is, a mental representation of some device, process, or system. For example, you have some type of representation of a car and how it works in your head. Such a representation is very helpful if your car won't start. Representational skills are very important for any job involving mechanical devices. However, such skills are much more broadly applicable and are used whenever jobs involve real objects (for example, surgery, firefighting) or social systems (for example, how to secure resources to complete a project in a large corporation).

Decision-making skills are techniques such as rules of thumb, mental simulation, or other processes that allow experts to arrive at appropriate decisions quickly and accurately. You probably have developed some rules about how to respond when you are driving and you see a traffic light turn yellow. Depending on your speed and distance from the intersection, you will ignore the light, speed up, or prepare to stop. You may have already made a decision to stop or not before the light turns. This allows you to make the decision very quickly and with some accuracy.

The process of cognitive task analysis involves the discovery of how experts complete their jobs. The analyst will attempt to determine what cognitive knowledge and skill are used and how the expert employs them to achieve superior performance. The analysis will link the tasks to mental processes. DuBois, Shalin, Levi, and Borman (1995) suggested organizing the relations of tasks and mental processes by creating a matrix in which knowledge requirements (declarative, procedural, generative, self) are crossed with task types (for example, technical tasks, organizationwide tasks, teamwork, communication). The resulting matrix helps ensure that the analyst includes all relevant tasks and knowledge requirements.

COGNITIVE TASK ANALYSIS METHODS

Seamster et al. (1997) described five classes of methods of data collection and analysis.

1. *Interviewing methods.* The interview can be used to ask SMEs about mental processes that are used in routine task performance or in critical situations. Structured interview formats have been developed for this method. For example, a police officer might be asked, "What do you need to know to make an arrest that will stand up in court?"

2. *Team communication methods.* Teams that communicate extensively in the course of completing their work can be observed or recorded. The communications among the team members can be analyzed for evidence of mental processes. For example, a firefighter's assessment of the source of a fire might be established by the kinds of questions he or she poses to other members of the team.

3. *Diagramming methods.* Tasks can be represented by various diagrams such as path-goal diagrams, decision trees, or other charts that indicate the relations among concepts. For example, one could diagram the steps involved in troubleshooting a car that won't start (Is the key in the ignition? Is the car in gear?).

4. *Verbal report methods.* Often job experts are asked to "think aloud" while they are completing a task. Occasionally, the experts may be asked to report on their thoughts before or after doing the work. The verbal reports are analyzed to infer goals, strategies, or automated skills.

5. *Psychological scaling methods.* Job experts may be asked to sort, rank, or rate a series of objects. The resulting categories or ratings are then analyzed through scaling or clustering programs to provide a quantitative representation of the results. This usually results in a representation of the relations among a set of concepts. For example, a pilot might be given a set of 25 cards, each of which presents a problem that might be encountered during flight (for example, lost radio contact, engine failure, ill passenger). The pilot would be asked to sort the cards into piles that are similar to one another. Several pilots would be asked to complete the sorting task. One possible analysis would be to represent the similarity of the problems as a map in which similar problems are close to one another whereas less similar problems are farther from each other.

A SIMPLE EXAMPLE

Seamster et al. (1997) analyzed the job of screener, which is a security job at an airport. The screener looks at X-ray pictures of carry-on luggage that passengers are bringing with them as they board the aircraft. It is the screener's job to spot guns, explosives, and other dangerous objects in the X-rays or by manual search so that such objects do not board the planes in the hands of the passengers. In addition to being accurate in spotting dangerous objects, the screener also needs to move quickly so that lines at the security checkpoints do not become so long that passengers become overwhelmed by rage. (If you've done much flying, you know what we are talking about.)

The purpose of the analysis was to enhance training for the position. The analysts focused on the decisions made by the screener. The screener examines each bag and must take one of three actions: pass the bag, search the bag manually, or stop the bag, physically capturing it in the screening machine. The cognitive task analysis was designed to better understand the process that expert screeners use to decide the proper course of action for each bag.

Analysts interviewed screeners away from the security checkpoints. Screeners were asked to provide incidents that had tested their skills. The next step was to have screeners provide verbal protocols ("think aloud") during actual task performance at the security checkpoint. Screeners mentioned what they were looking at in each picture and how they decided what to do with each bag. The analysts also directly observed the work by standing behind the screeners as they worked. Analysts were allowed to ask questions, such as how they might hide a weapon in a briefcase that had just passed through the machine.

The cognitive task analysis resulted in a model of the screener's decision about each bag. The model can be represented as a series of steps. The screener looks at the X-ray and decides whether there is anything odd or dark (potentially of interest) in the bag. If there is not, then the bag is passed. If there is something of interest, the screener takes a closer look at it to determine what it is. If it is a threat, the screener will trap the object in the machine by stopping it. If the screener does not recognize the object as a threat, he or she will determine whether the object is large enough to conceal a threat. If it is, the screener will search the bag. If it is not, the screener will pass the bag.

The analysts concluded that one main difference between novice and expert screeners is the large "library" of stored images that experts have. This library allows experts to identify most of the things that they see in the X-ray pictures. (This is an automated skill that is virtually effortless for the expert screener.) Novices cannot identify many of the same objects, and they end up searching many more pieces of baggage than do the experts.

Cognitive task analysis can be used for several important purposes, including reducing human error, improving training, and increasing systems reliability. Errors might be reduced in several ways. For example, some jobs such as piloting an aircraft involve a very large amount of information that is displayed visually. If you've ever peeked into the cockpit of a commercial jet, you know what we mean. To help avoid missing crucial information (such as approaching a mountain at night), some information is displayed as auditory warnings ("pull up"). Or errors might be reduced by determining common mistakes in identifying cues. It is important in the military that soldiers can tell friend from foe (for example, tanks, aircraft) quickly and accurately through visual inspection, for example, and people can be trained to do so.

RELIABILITY AND VALIDITY

Because cognitive task analysis is not one but rather many different analyses, it is difficult to discuss reliability and validity as one would for a single procedure in which the steps and materials are set. However, Seamster et al. (1997) have noted that the results may vary depending on the method used and the particular experts studied. They noted that because cognitive task analysis focuses on experts, it is necessary to study actual experts during the study; that is, the SMEs selected for the study must be able to perform the job at consistently superior levels. They recommended using at least two different measures of expertise (for example, time in job, measures of superior performance, peer nominations) to choose the SMEs for the study. They did not provide a minimum number of SMEs to use in a given study. However, because cognitive task analysis allows for individual difference in performance, it is likely that the results will be influenced by the choice of SMEs for study and therefore that multiple SMEs be studied whenever this is feasible.

With regard to validation, very little has been published to date. We note here that as with any job analysis method, much of the validity resides in the usefulness of the technique for its intended purpose. To date, cognitive task analysis has been applied to training, systems design, and performance measurement with apparent success. Seamster et al. (1997) advised that conclusions from cognitive task analysis should always be based on two different methods of data collection. They further advised to use one method to develop models or hypotheses and then to select a second method that will provide the most efficient test of the hypotheses.

REMARKS ON COGNITIVE TASK ANALYSIS

At its best, cognitive task analysis provides unique information about mental processes at work. Cognitive task analysis illuminates how experts perform the job, and this can be useful for many applications, especially training. However, cognitive task analysis is also expensive and time consuming. Increased experience (dare we say expertise?) will help clarify the conditions under which the results of cognitive task analysis justify its expense.

Chapter Summary

We have described several worker-oriented methods of job analysis. We began with the job element method (JEM), which is the earliest method devised. JEM analyzes the job demands on the worker into pieces that jobholders understand to be the important elements of the work. Such elements are clearly related to work samples, which are in turn useful for such applications as selection, performance evaluation, and training. JEM can also be used to select tests that are not job samples or simulations with the use of the J-coefficient.

We next turned to the Position Analysis Questionnaire (PAQ), which is possibly the most widely used of the worker-oriented methods. The PAQ describes jobs in terms of about 300 standard requirements, such as use of pictorial materials, amount of planning, requirement for transcribing, use of mathematics, use of long-handled tools, operation of powered water vehicles, and exposure to vibration. The PAQ was developed for selection and job evaluation, but it has seen much wider application. The reliability of the PAQ's individual items appears rather low, but the reliability of the scale scores appears adequate. The PAQ may not be the best choice to analyze closely related but different jobs because of its generic elements. On the other hand, these generic elements permit us to do some things, such as cluster jobs into families, quite well.

In the Other Trait-Based Worker-Oriented Methods section, we described five other job analysis methods. Three of these were described in terms of lists of traits. Both the Threshold Traits and the Ability Requirements Scales offer extensive sets of human abilities linked to psychological tests, whereas Threshold Traits also include motivational and social job requirements. The Occupational Reinforcer Pattern shows a list of traits related to human motives at work. The other two methods were chosen for their serious treatment of tools and equipment at work. The AET was developed from an ergonomic approach that seeks to reduce the stress of job demands on people through proper job design, especially where people interact with machines and tools. The Job Components Inventory contains a section with 220 items relating to skills needed for using tools and equipment.

The final section of the chapter described cognitive task analysis, which is the newest of the worker-oriented approaches. Cognitive task analysis seeks to understand and describe the mental processes used by experts during job performance. Unlike the other methods in this chapter, cognitive task analysis is not a single approach with steps that can be articulated prior to the specific project. Rather, cognitive task analysis is a flexible set of tools, all of which have the same general aim. Cognitive task analysis generally starts with a behavioral, task-oriented job analysis and subsequently seeks to understand and represent the mental processes that experts use to perform the tasks of interest. Although it seems promising for such purposes as training, cognitive task analysis's value as a job analysis approach is still in the testing stage.