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Cognitive Styles of Forest Service Scientists and Managers in the Pacific Northwest

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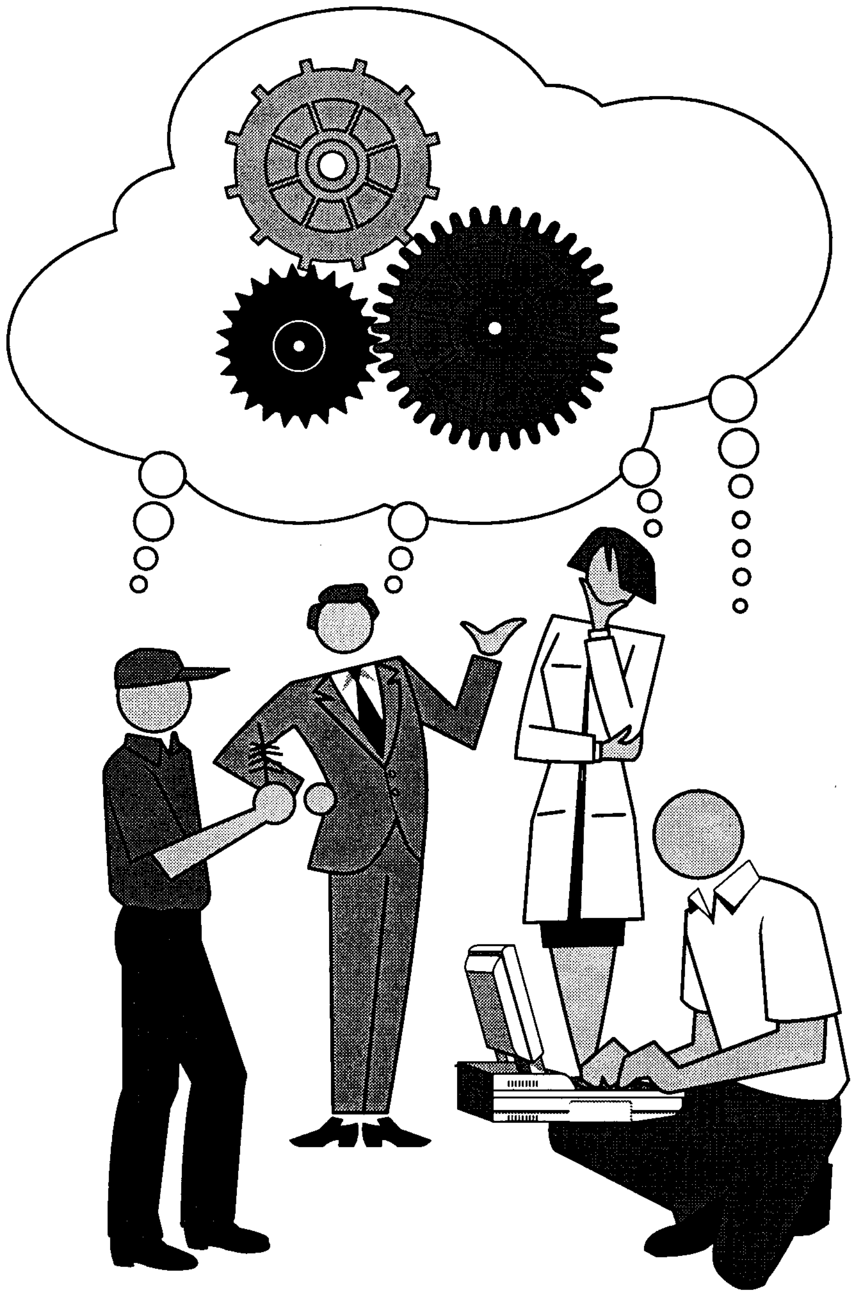

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Abstract

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Preferences of executives, foresters, and biologists of the Pacific Northwest Research Station and executives, District Rangers, foresters, engineers, and biologists of the Pacific Northwest Region, National Forest System (USDA Forest Service), were compared for various thinking styles. Herrmann brain dominance profiles from 230 scientists and managers were drawn from Forest Service archives. Results showed that employees used diverse thinking styles; 24 different profiles were found and employees used 21 of 24 available adjectives to describe their own styles. All occupational groups preferred a combination of analytical and integrative thinking. Engineers had the highest score for analytical thinking; District Rangers had the lowest. District Rangers had the highest preference for feeling-based, interpersonal thinking; engineers had the lowest. Research biologists and executives had low preference for detailed, sequential thinking. Research executives had less preference for interpersonal thinking than management executives. Implications for the agency are discussed.

Keywords: Cognition, thinking, personality, teams, management, Forest Service scientists, managers.

Contents

Introduction

The National Forest System of the U.S. Department of Agriculture, Forest Service, manages 192 million acres (78 million ha) of land in 44 states (Gorte and Cody 1995). The mission of the Agency changed from the protection of forests and rangelands prior to World War II to multiple use, with an emphasis on timber production, after 1950. Changing societal values led to legislation in the 1960s and 1970s that required the National Forest System to incorporate interdisciplinary teamwork and public involvement in planning. The resulting planning processes led to changes in Forest Service culture that were accompanied by increased internal and external conflict (Kennedy 1988, Mohai and Jakes 1996). Ecosystem management was instituted as the natural resources management policy for the National Forest System in 1992, and survey research (Bull 1994) suggested that additional cultural change would be necessary to implement this policy.

Historically, the Research branch of the Forest Service produced information pertinent to the management of Federal, state, and private lands but was not directly involved in land management policy, planning, or implementation. Increased public scrutiny and criticism, legislative requirements for incorporation of complex scientific concepts into land management planning, and congressional challenges to management policies of the National Forest System, particularly in the Pacific Northwest, have led to increased participation by research scientists in interdisciplinary research teams and management of National Forests. Participation in management ranges from consultations at the local level to leadership of large, interdisciplinary teams at the regional level. The addition of scientists of various disciplines to interdisciplinary teams of managers has, expectedly, led to further conflict within planning teams. Ties between these two branches of the Forest Service also have been complicated by consolidation of support services such as personnel, financial, and procurement management.

Lands managed by the National Forest System are grouped into nine geographic regions. The Pacific Northwest Region (R-6) manages land in 19 National Forests in Oregon and Washington that are further divided into 88 Ranger Districts. The R-6 Management Development Group has implemented training aimed at developing the ability of employees to work in teams of diverse people. A recent addition to this training has been the use of the Herrmann Brain Dominance Instrument (HBDI) (Herrmann 1990, 1996), a self-administered questionnaire that assesses individual preferences for cognitive (thinking) styles. Thinking styles include A-analytical and logical, B-conservative and sequential, C-emotional and interpersonal. and D-integrative and holistic. Four modes of thinking are derived from the HBDI: cerebral, limbic, right-brain, and left-brain.

The Research branch of the Forest Service also is divided geographically. The Pacific Northwest Research Station (PNW) conducts research in Oregon, Washington, and Alaska. Scientists from PNW historically have not been involved in R-6 manager-development programs. In 1996, however, the R-6 Management Development Group conducted an HBDI survey of PNW scientists. Thus, an archival database of HBDI profiles of Forest Service scientists and managers of various disciplines in the Pacific Northwest existed for the first time.

The purpose of this thesis was to determine if there is either (1) within- or among-group homogeneity in cognitive preferences that could contribute to "group-think" or (2) within-group homogeneity and between-group heterogeneity in cognitive preferences that could contribute to conflict among occupational groups in the Forest Service
in the Pacific Northwest. Groupthink is a mode of thinking that people engage in

when they are involved in cohesive groups, and striving for unanimity overrides motivation for realistic appraisals of alternative courses of action (Janis 1983). Of particular interest were differences between management and research, line and staff, and disciplines oriented toward commodity production versus disciplines oriented toward environmental protection. Several *a priori* hypotheses were developed based on the Herrmann (1996) experience with the HBDI:

- Scientists emphasize cerebral thinking.
- Engineers exhibit a preference for a single thinking style, A (rational).
- Management staff and line exhibit preference for left-brain thinking.
- Executives exhibit preference for cerebral thinking.

Because the database was archival and not based on random sampling, this study was exploratory in both summary statistics and hypothesis testing; results cannot necessarily be generalized and are not determinative of cause and effect.

Literature Review

"The assessment of personality is as old as humanity itself' (Aiken 1996:30). Descriptions of types and temperament date from the 4th century B.C. Temperament refers to early developing, stable, individual differences in behavioral style. Personality is a broader concept, containing characteristics such as values, attitudes, and interests (Angleitner and Ostendorf 1994). In other words, "temperament is the rootstock of personality" (Ornstein 1993). A complete definition of personality includes affective, cognitive, behavioral, and mental variables. Affective assessment is measurement of noncognitive characteristics, including temperament, emotion, interests, attitudes, personal style, and other behaviors, traits, and processes. Cognitive assessment is defined as the measurement of intellective processes, such as perception, memory, thinking, judgment, reasoning, and problem solving (Aiken 1996). Learning and communicating technical information are also intellective. Various instruments may assess cognition, affect, or the entire personality.

Psychoanalytic theories (e.g., those of Freud, Jung, Adler, and Rogers) and various trait-factor theories (those of Cattell and Eysenck) were the primary influences on modern instruments of personality assessment (Aiken 1996). For example, the widely used Myer-Briggs Type Indicator (MBTI), with four bipolar factors, was derived from Jungian theory (Myers and McCaulley 1985) and later subjected to factor analysis (Harvey and others 1994, 1995). The number of personality factors that have been proposed ranges from 3 to 16 (De Raad and others 1994). Most systems of personality assessment (including MBTI, California Psychological Inventory, Cattell's 16 Personality Factors, and Minnesota Multiphasic Personality Inventory) have been challenged as not replicable or as contraventions of psychometric rules (Eysenck 1994). But there is now an emerging consensus on five factors (the Big Five) underlying both temperament and personality that are robust across groups, languages, and cultures (Angleitner and Osterndorf 1994, De Raad and others 1994, Halverson and others 1994). The factors are I-extraversion, II-agreeableness, III-conscientiousness, IV-emotional stability, and V-intellect or openness to experience (Goldberg and Rosolack 1994).

In this review, I first describe the development, application, and acceptance of the HBDI, which is an assessment of preferences for various cognitive styles. Next, I relate the HBDI to the Big Five, theories of learning and memory, and components of the intelligence quotient (IQ). Because many American psychologists have a negative view of personality types (Aiken 1996, Springer and Deutsch 1993), and because any useful system of types is perhaps reductionistic, I will review the validity of the HBDI according to the criteria of Messick (1995). Notwithstanding skepticism of some psychologists (e. g., Hines 1985) about the theoretical validity of personality assessments, the practical utility of types in training for interpersonal and interaction skills (and for personal growth) is beyond doubt (Aiken 1996; Hequet 1995; Herrmann 1990, 1996; McClure and Werther 1993; Myers and McCaulley 1985).

Development and Refinement of the HBDI

The HBDI was developed by Ned Herrmann when he was head of manager edu-- cation for General Electric. Herrmann became intrigued by the concept of artistic creativity in 1975 while serving as the president of the Stamford Art Association. Together with the association's directors, Herrmann convened a panel on creativity. In preparing for the panel, Herrmann encountered the literature on brain specialization, including the writings of Broca (aphasia), Wernicke (aphasia), MacLean (triune brain), Sperry (split-brain experiments), and Ornstein (electroenceph-alographic evidence of specialization) (Herrmann 1990). Simultaneously, Mintzberg (1976) was stimulated by brain lateralization studies (see Springer and Deutsch 1993 and Davidson and Hugdahl 1995 for reviews of lateralization research) and Ornstein's work (see reviews in Ornstein 1993 and Ornstein and Thompson 1984). Mintzberg proposed that hemisphericity (left-brain vs. right-brain differentiation in cognition) was the reason for organizational discrepancies at the policy level: the techniques of planning and analysis had little influence on the function of top managers. Doktor and Bloom (1977) contrasted the EEG alpha wave activity of executives and systems analysts and concluded that systems analysts engaged primarily the left cerebral hemisphere and executives engaged primarily the right cerebral hemisphere. Doktor and Bloom concluded that anatomic differentiation of cognition is the root of lack of communication and understanding between the two groups. Oltman and others (1979) provided further EEG evidence of a relation between cognitive style and interhemispheric differentiation. Zoccolotti and Oltman (1978) used visual field dependence techniques to provide evidence of lateralization.

In 1976, Herrmann (1990, 1996) began conceptualizing an instrument based on left-brain vs. right-brain preferences that could be used in the corporate workplace. Eventually, the concept was expanded to four quadrants: left and right cerebral hemispheres and left and right limbic system. Four broad thinking styles were assigned to the quadrants: A-analyze (upper left), B-organize (lower left), C-personalize (lower right), and D-strategize (upper right). The result was the whole-brain model, presented as a metaphor, not a schema. Herrmann developed a 120-question instrument, the HBDI, to assess preferences for the four styles; 85 questions were lexical, asking for choices on words describing strength in work elements, thinking style, and self-image (see table 1). The HBDI produces profile scores for each of the four quadrants (A, B, C, D) and a four-digit profile based on preference (1), use (2), and avoidance (3) of each of the four thinking styles (e.g., 1132). It is assumed that each person must use all four thinking styles to function

Table 1—Descriptors of thinking styles in Herrmann's four-quadrant whole brain model

System	Left brain	Right brain
Cerebral hemisphere	A-quadrant: analytical factual logical mathematical quantitative rational	D-quadrant: conceptual holistic imaginative innovative integrative intuitive
Limbic	B-quadrant: controlled conservative detailed organized sequential planning	C-quadrant: emotional interpersonal intuitive kinesthetic spiritual symbolic

Source: Herrmann 1996.

fully, but that some styles are preferred to others and preferred styles are used more frequently than others. Four percentage scores are provided for four modes (left, right, cerebral, and limbic); the scores are complementary (sum to 100 percent) for left and right and for cerebral and limbic modes. The HBDI also incorporates a simple, self-assessment introversion-extroversion scale.

In 1979, Herrmann and General Electric contracted with the WICAT Education Institution (a nonprofit research and development organization) for a series of studies to determine the construct validity of several of Herrmann's instruments and methods. Six studies were conducted by C. Victor Bunderson (later vice-president of Research Management, Educational Testing Service, Princeton, NJ) and James B. Olsen and their students (Bunderson 1990). These studies addressed content-related validity, criterion-related validity, face validity, construct validity, and test-retest reliability.

The first study combined a literature review, to develop a battery of measures against which HBDI scores could be compared, and a preliminary examination of construct validity. The second study was a factor analysis of 31 profile scores from 15 different instruments administered to 143 people (52 General Electric employees and 91 students from Brigham Young University). This external construct validation was used to understand and clarify the concepts and constructs related to the HBDI.

The third study was an internal construct validation based on 438 participants in General Electric education workshops. An initial factor analysis with promax rotation of 91 item scores was used to construct 12 subscores that were subjected to a second factor analysis, which yielded two factors and a third-order factor that became the basis for refining the HBDI. Refinements included the construct of four brain (thinking style) quadrants (A-upper left, B-lower left, C-lower right, and D-upper right) aligned along two factors: A-C (analytical and rational vs. interpersonal and emotional) and B-D (planning and organizing vs. innovative and integrative). The third-order factor was bipolar left-right brain dominance.

The fourth study was a rescoring of study 2. This analysis resulted in a new scoring protocol and an expansion of the HBDI to 120 items. The fifth study replicated the second study, but used the new brain dominance profile scores. This study substantiated the findings of the earlier studies and showed that all new items functioned properly. The same two bipolar factors and the same third-order factor were found again.

The sixth study applied the 120-item HBDI to 7,989 subjects (two-thirds men, one-third women) surveyed during 1984-86 in a variety of workshops, public presentations and individual consultations by Herrmann. Factor analysis with promax rotation was conducted by Kevin Ho for his doctoral dissertation at Brigham Young University and reported by Bunderson (1990). Because the initial factor analysis dealt with items, factor scores were developed for each subject for each factor. The 7,989 scores on each of the factors were subjected to a new factor analysis. Again the A-C (explaining 35 percent of the variance) and the B-D factors (explaining 58 percent of the variance in scores) were found; the two factors had a correlation of 0.37. Again, a third-order left--right factor was found (accounting for 39 percent of the common variance). Nine scores were developed from the 120 items. The HBDI was repeated 78 times on a large sample of the same individuals. Test-retest reliabilities were 0.86-0.97 on the first eight scores (left, right, A, B, C, D, cerebral, and limbic). The ninth score was introversion-extroversion and had a test-retest reliability of 0.73. Bunderson (1990) concluded that the overall pattern appeared to be stable over time but acknowledged that those thinking style preferences could change over time, especially with conscious effort on the part of the individual. He stated that there was generalizability across situations, contexts, sex, and cultures but did not document the basis for the claim.

Applications

Suggested uses of the HBDI include better understanding of self and others, enhanced communication, enhanced teaching and learning, better management, counseling, and building composite learning groups (Bunderson 1990). Herrmann (1996) illustrates various applications of the HDBI and the whole-brain model. Whole-brain technology consists of some analytic procedures (1) to determine if presentations or written materials are adequately addressing learning preferences associated with different profiles (called proforma analyses), and (2) to design teaching and technology transfer instruments to appeal to different learning styles. The HBDI also is used in team building, either alone or with other training, such as the managerial grid (Blake and Mouton 1985).

By 1989, more than 500,000 people had completed the HBDI in workshops and consultations. Herrmann (1990) provided an overview of profiles in the workplace but did not present quantitative data. New summaries of data on occupational norms (N = 113,000 profiles) were reported in 1996 (Herrmann 1996) but without measures of dispersion. Few published reports on workplace applications seem to exist. This lack of published information is not surprising given the proprietary nature of the HBDI and the confidentiality of workplace interventions. Schkade and Potvin (1981) used the HBDI to identify 12 clearly left-brained accounting students and 12 clearly right-brained art students. The students were subjected to electroencephalograms. The results demonstrated significant differences ($p < 0.001$) in active processing as indicated by brain waves: accountants emphasized the left, artists, the right. Doktor and Bloom (1977) also showed differences among occupational groups in hemispheric power ratios. Coulson and Strickland (1983) compared 23 superintendents of schools to 22 business executives. Superintendents had higher left-hemisphere scores; executives had higher right-hemisphere scores. Executives had dual primary cognitive preferences for logical (A-quadrant) and creative (D-quadrant) thinking and avoided organization (B-quadrant thinking). Superintendents had high scores on organization (B-quadrant) and interpersonal (C-quadrant) thinking, but had low preference for conceptual (D-quadrant) thinking.

Simultaneously with the development of the HBDI for workplace application, there was an explosion in the popular acceptance of the brain differentiation-cognitive style model. (e.g., Nadel and others 1990). The metaphor is easily grasped, certainly much more easily understood by the general public than either Jung's theory as extended by MBTI or Cattell's 16 Personality Factors. Even the MBTI was related to hemispheric dominance (Shiflett 1989). The popularization of an anatomical link to cognitive style caused concern on the part of neuropsychologists (Springer and Deustch 1993) and among trainers (Hines 1985). Accumulating research revealed increased complexity and less evidence for clearcut brain specialization and discrete cognitive styles (see Davidson and Hugdahl 1995 for a synthesis). Still, the use of brain evolution and anatomy as a metaphor for illustrating interpersonal differences is a powerful technique (Merlin 1991, Ornstein 1993, Sternberg 1989). Harrington (1995) reports that left-brain and right-brain metaphors have powerful appeal and startling resonance with post-1950s culture in the United States. Materials that accompany the HBDI provide verbal and visual metaphors that appeal to all major cognitive styles. The utility of the HBDI in the workplace is receiving broad recognition and acclaim (Gorovitz 1982, Nadel and others 1990). For example, Herrmann has been inducted into the HRD Hall of Fame (Hequet 1995).

Evidence has been accumulating for a uniform structure of general personality (Croom and others 1989, Halverson and others 1994, Schueger and Allen 1986). Elements of the Big Five are related to the HBDI. Both have an introversion-extroversion factor. Agreeableness (Big Five factor II) is related to C-quadrant (interpersonal, feeling-based) thinking styles; conscientiousness (III) is related to B-quadrant (planned, detailed, and organized); emotional stability (IV) is related to A-quadrant (rational, logical); and intellect or openness to experience is related to D-quadrant (creative, innovative, intuitive) thinking.

The HBDI and Other Measures of Personality

There are three dimensions to intelligence, as measured by IQ (Hunt 1995): fluid intelligence, crystallized intelligence, and visuospatial reasoning. These dimensions are related to thinking as a process of creating a mental representation of the current problem, retrieving information that appears relevant, and manipulating the representation to obtain a solution. Thus, B-quadrant thinking can be thought of as using crystallized intelligence to bring to bear previously required problem-solving skills to solve familiar problems. A-quadrant thinking can be thought of as using previously acquired problem-solving skills and fluid intelligence to solve new and unusual problems (through analysis of the new problem), and D-quadrant thinking can be thought of as using visuospatial intelligence to develop new and creative solutions to old or new problems. Whereas IQ is a measure of capacity, the HBDI measures neither aptitude nor competence, only preference. Payne and Evans (1985, 1986) examined 40 female occupational therapy students and found some strong relations between HBDI right cerebral and total cerebral scores and scores on the Scholastic Aptitude Test (SAT). There was a modest relation between limbic scores and SAT M-scores. There was no relation between laterality and grade point average and an inverse relation between left limbic scores and grade point average. Examination of 98 Ph.D. candidates found a moderate relation between left cerebral and total cerebral HBDI scores and Graduate Record Exam (GRE) scores, GRE-Q and GRE-T (Payne 1988). Limbic scores were inversely related to GRE; left-hemisphere dominance was positively related, and right-hemisphere dominance was negatively related, to GRE scores. No emotional component has been identified in IQ or other academic aptitude tests; however, the HBDI measures preference for thinking related to emotions and interpersonal relations.

Two theories of learning, behaviorism and cognitivism, have theoretical and empirical support (Petri and Mishkin 1994). According to Petri and Mishkin, behaviorism regards learning as automatic, beyond awareness, and based on reinforcement, whereas cognitivism suggests individuals can acquire and store information that can be combined with new information to lead to new behavior (novel solutions). Petri and Mishkin proposed a two-system model with one system storing memories (cognitive) and the other developing habits (noncognitive). Memory and habit are associated with the limbic system. Presumably the formation of novel solutions depends on analyzing and integrating memories and synthesizing new solutions in the cerebrum. Thinking and learning, however, are complex and involve the whole brain (see the review of adaptive resonance theory by Grossberg 1995). The HBDI is fully compatible with current theory of learning.

Personality can be thought of as the result of processing temperament through socialization and acculturation. Thus, thinking styles should reflect cultural dimensions. Ray (1996) describes three cultural streams in the United States. The traditionalists are conservative and exemplify B-quadrant thinking. Modernists, with a belief in technology and rational thought, exemplify A-quadrant thinking. The emerging integral culture is characterized by humanism, spirituality, and creativity (a combination of C- and D-quadrant thinking). Thus, thinking style can be thought of as embedded in personality along with intelligence, affect, and sociopolitical values (Angleitner and Ostendorf 1994, De Raad and others 1994, Goldberg and Rosolack 1994).

Validity of the HBDI

Messick (1995) suggests that current concepts of validity of psychological assessments are inadequate and proposes six standards for all educational and psychological measurement: content, substance, structure, generalizability, external relevance, and consequence. Content includes content relevance, representativeness, and technical quality. Structure includes fidelity of scoring to the knowledge, skills, ability, and other characteristics assessed by the instrument. Generalizability is across populations, settings, and tasks. Content, structure, and generalizability were evaluated by Bunderson (1990) and found to be sufficient. Generalizability is reported by Herrmann (1990, 1996) across cultures and occupations. External relevance includes convergent and discriminant evidence from multitrait-multimethod comparisons and applied utility. Bunderson conducted such multitrait-multimethod comparison and I, in this review, have related the HBDI to the Big Five and other types of personality assessment. Both examinations found high external relevance. Herrmann and Bunderson both discuss the applied utility of the HBDI. Hequet (1995) reports widespread acceptance of the utility of the HBDI for training. Consequence includes the value implications of score interpretation as a basis for action and actual and potential consequences of test use, especially in regard to bias, fairness, and distributive justice. Herrmann is adamant that score interpretation should be value free. The utility of the HBDI lies in its value for personal insight and for appreciating the value of diversity. The instrument is designed to enhance communication and understanding and is not promoted for use in selecting applicants for jobs. The instrument does not purport to measure ability or competence, only preference.

The substance of an assessment refers to its theoretical rationale. Herrmann (1990, 1996) conceived the HBDI after a review of brain evolution *(sensu* McLean 1985) and lateralization studies. A number of studies relate brain dominance, occupation, and thinking style to electroencephalographic activity (e.g., Doktor and Bloom 1977, Oltman and others 1979, Schkade and Potvin 1981). But Herrmann states that his model is a metaphor, not an exact representation of function as it relates to anatomic specialization. The metaphor is not contradicted by the most recent research on brain asymmetry and lateralization of function (see papers in Davidson and Hugdahl 1995 for a review) as suggested by Springer and Deutsch (1993). The idea that the brain is organized into distinct areas of relative functional autonomy and specialization is a basic principle of cognitive neuroscience. However, the brain realizes its functions by the conjoint activation of several component structures, each performing specific operations. Psychological and cognitive functions are no longer viewed as unitary processes but as compositions of subprocesses organized in specific ways (Sergent 1995). The claim that the cerebral hemispheres have different visual perceptual strengths is no longer controversial (Brown and Kosslyn 1995). But the exact relation between brain asymmetry and side differences in language and visuospatial skills is unknown (Galaburda 1995). Even simple tasks for visual information processing involve a number of information-processing subsystems and interactions among subsystems; it is impossible to indicate which cerebral hemisphere is superior for an entire task (Hellige 1995). Face recognition alone involves both left and right hemispheres (Sergent 1995). Hellige suggests the right hemisphere is superior to the left hemisphere for the processing of global events; the left hemisphere is superior for local events. The left hemisphere is specialized for language processing, but each hemisphere subserves multiple listening functions (Hugdahl 1995a). Fundamental asymmetry controls functions related to emotion; left and right hemispheres are specialized for approach and withdrawal processes, respectively (Davidson 1995). Associative learning conditioned to emotionally relevant stimuli takes place in the right hemisphere with the amygdala important in fear conditioning. Limbic structures are clearly involved in regulation of emotional affect, with the right cortex regulating autonomic reactivity (Hugdahl 1995b). The most fundamental division of corticolimbic architecture is not left-right, however, but dorsal-ventral. There are complex relations among vertically integrated circuits, and interpreting their function in relation to human emotional behavior is a difficult and controversial process (Liotti and Tucker 1995). Thus, Herrmann's whole-brain model and the nomenclature of the HBDI are best viewed as a metaphor, and as a metaphor they represent reasonably well Sergent's view of cerebral lateralization of functions, in which the two hemispheres interact in distributing and acquiring their respective competencies with close interdependence, such that the modularity of the brain is embedded within a highly interactive central nervous system. The metaphor also reflects Davidson's and Hugdahl's respective views on the influence of cerebral asymmetry and cerebral-limbic differentiation in regulation of emotion and affective style.

Method

This was an archival study. The R-6 Management Development Group and Mark Wilcox (a consultant) surveyed employees of R-6 and PNW during 1992-96 with the HBDI (Herrmann 1990, 1996) in conjunction with managerial grid training and team-building exercises. The HBDI is a proprietary, copyrighted survey instrument; the details of the instrument were reported by Herrmann. The HBDI consists of 120 questions including name, sex, educational focus, occupation, handedness, best and worst academic subjects, work elements, key descriptors of self, hobbies, diurnal energy level, motion sickness, choices among personally most descriptive adjective pairs, an introversion-extroversion scale, and a Likert scale (strongly agree-strongly disagree) for 20 statements about cognitive style. Summary scores and items for the HBDI were obtained from the archives.

Procedure

I obtained a list of names of individuals and their occupations (as the individuals reported them) from Wilcox (the consultant) through the auspices of Charles DeRidder, Director of Management Development, R-6. DeRidder also provided the General Service (GS) grade levels (salary ranges that indicate occupational maturity as well) for the individuals. Only GS-11s and above were considered because GS-11 is the minimum grade for scientists and is the beginning grade for mid-level management.

I reviewed the list and concluded that adequate sample sizes existed for the following occupational groups: research executives (Station Director, Deputy Directors, Assistant Directors, and Program Managers with science backgrounds); management executives (Forest Supervisors and their deputies with technical backgrounds); management frontline (District Rangers); research foresters (foresters, silviculturists, pathologists, economists, forest product specialists, and forest inventory specialists); research biologists (including wildlife biologists, fisheries biologists, forest ecologists, and botanists); management foresters; management engineers; and management biologists. Only one level of line (executive) exists in PNW. Front line District Rangers were grouped separately from executive line in R-6 not only because of functional differences, but also because District Rangers have long been considered barometers of Forest Service culture (Bultena and Hendee 1972, Carroll and others 1996, Sabatier and others 1996, Twight and Lyden 1989). Disciplinary groupings for staff were based on education (forestry departments and colleges vs. other departments and colleges) that reflected orientation (commodity vs. amenity or environmental values). If ambiguity existed in the case of scientists, research program affiliation (for example, production vs. ecosystem processes) was used to resolve the ambiguity. Ambiguities in occupations of management staff were resolved by not selecting ambiguous cases. The commodity versus amenity (or production vs. process) groupings were chosen because these groups are most often contrasted in the literature (Kennedy 1985, 1988; Miller and Gale 1986; Mohai and Jakes 1996; Shannon 1992; Tipple and Wellman 1989; Twight and Lyden 1989), and sample sizes were inadequate for contrasting all the self-reported occupations or subgroups such as wildlife biologists, fisheries biologists, and botanists.

I returned a list of 230 Forest Service employees to DeRidder and Wilcox. Wilcox then provided me with data in the form of anonymous individual records grouped by occupational category. Data included demographic variables: sex, date of birth, and ethnicity. I converted dates of birth to age as of December 1996. Data calculated from the HBDI by Wilcox and provided to me included:

- A four-digit profile (e.g., 1132) composed of rankings (1 = prefer, 2 = use, 3 = avoid) based on self-report scores in the sequence of the four quadrants (A-analyze, B-organize, C-personalize, D-strategize).
- Numerical scores for each of the four quadrants.
- Percentage scores for modes of thinking (left, right, cerebral, limbic).
- Self-reported key personal descriptors.

Summary statistics were calculated by occupational categories for all variables. Summary statistics included means, standard errors, 95-percent confidence intervals, skewness, and kurtosis. Statistical significance of skewness and kurtosis were tested with a t-test (a = 0.05) comparing the statistic to zero with the standard error defined as $(6/n)^{1/2}$ for skewness and $(24/n)^{1/2}$ for kurtosis (Sokal and Rohlf 1995). I used Levene's statistic to test for homogeneity of variances of groups to be examined with analysis of variance (ANOVA) or multivariate ANOVA (MANOVA). I used one-way ANOVA to test for differences in age among occupations and Tukey's HSD to determine how occupations differed. I used MANOVA, Box's M-Test of equality of covariance matrices, and profile plots of estimated marginal means to test for differences among occupations in scores on the four HBDI quadrants. Because homogeneity of variances, equality of covariance matrices, and kurtosis were significant or near significant for a number of comparisons, I repeated the comparisons by using one-way ANOVA with Waller-Duncan comparisons (*a* = 0.05) and Kruskal-Wallis nonparametric ANOVA. I used chi-square goodness-of-fit tests to test for differences among occupations in preferences for the four modes of thinking and key descriptors. Sample sizes were small, however, for the number of categories.

Sample

Both PNW and R-6 were reducing markedly the size of their workforces during 1992-96; in addition, there was turnover in many jobs. Thus, precise data on the population from which the samples were drawn were not available. In 1996, PNW employed about 120 scientists during the survey period; 76 percent were male and ages ranged from 32 to 68 years. Fifty-nine responded to the HBDI survey (table 2). The sample of research executives was an inventory. About 50 percent of scientists were sampled (all were sent surveys by the Management Development Group). In 1996, R-6 employed 1,805 professionals (GS-5 and above); 70 percent were male and 62 percent were Caucasian. About 65 percent of management executives and 35 percent of District Rangers were sampled. The sample of technical staff above the GS grade of 11 was greater than 10 percent. Samples appeared representative of the populations from which they were drawn. Staff samples were not random samples; however, unknown biases could exist in self-selection and supervisor selection for training. Not all respondents answered questions about ethnicity and age; sample sizes for these categories are 15 percent lower than total sample size.

Table 2—Demographic attributes of the sample returning HBDI surveys, 1992-96

Occupational category	Number	Male	Caucasian	Age *M* (*SE*)
		- - - *Percent* - - -		Years
Research:				
Executives	11	100	100	57 (3)
Foresters	29	96	92	46 (2)
Biologists	19	68	100	46 (2)
Management:				
Executives	13	85	100	53 (1)
Frontline	31	68	69	47 (1)
Foresters	52	81	85	45 (1)
Engineers	21	76	78	44 (2)
Biologists	54	70	91	43 (1)

Results

Forest Service archives contained 230 HBDI profiles that could be assigned to eight occupational categories of interest. Most individuals in each occupational category were middle-aged white males, representative of PNW and R-6. Executives were significantly older than front line, staff, and scientists (Levene's statistic for homogeneity of variances = 1.86, *of* = *7* 194; $p = 0.08$; $F = 6.66$; *df* = *7* 194; $p < 0.01$). Categories for biologists and frontline (District Ranger) had more female members (30-32 percent) than categories for executives, foresters, and engineers (0-24 percent female members) .

Preferences for Thinking Styles

Overall, the sample showed tendencies toward A-quadrant, analytical thinking and D-quadrant, integrative thinking (table 3). I found no significant skewness, but 10 of 32 distributions were platykurtic and one was leptokurtic (engineers' low scores for emotional thinking styles). Levene's test showed equality of error variances, with *F*s = 0. 6-1.6, *df* = 7, and ps =0.13-0.75. Box's M-test, however, suggested heterogeneity in covariance matrices *(F = 1.34, df = 70,* 15832, $p = 0.03$). Therefore I used Pillai's trace test statistic and found significant differences in preferences among occupations *(V* = 0. 195; $F = 1.624$; *df*= 28, 888; p = 0.02). Profile plots (fig. 1) showed that engineers had significantly higher preference for A-quadrant (rational) thinking than did other occupations. Research executives and research biologists had low preferences for B-quadrant (detailed) thinking. District Rangers had higher preferences for C-quadrant (interpersonal) thinking styles than did other occupations; engineers had the lowest preference for C-quadrant thinking. Engineers also had the lowest preference for D-quadrant (integrative) thinking. One-way ANOVA confirmed significant differences among occupations in preferences for A-quadrant thinking *(F* = 2.85, *of* = 7, 222, p < 0. 01) and C-quadrant thinking *(F* = 2.78, *df*= 7, 222, $p < 0.01$). Kruskal-Wallis nonparametric ANOVA also confirmed occupational differences for A-quadrant (x^2 = 18. 2, *df*= 7, p = 0.01) and C-quadrant ($x^2 = 19.0$, *df = 7, p* < 0.01) thinking. Waller-Duncan comparisons confirmed that engineers had higher preferences for

Table 3-Mean quadrant (A, B,C,D) scores (with standard errors) for thinking styles and mean percentage preferences (with standard errors) for thinking modes for 8 occupational groups in the Forest Service, Pacific Northwest, 1992-96

	Thinking styles				Thinking modes	
Occupation	A	B	C	D	Cerebral	Left brain
	- - - - - - Score (SE) - - - - - -				*- Percent (SE) -*	
Research:						
Executives	88 (4)	60 (8)	59 (5)	87 (10)	62 (4)	51 (4)
Foresters	83 (4)	64 (3)	58 (4)	83 (4)	58 (1)	51 (2)
Biologists	78 (6)	58 (4)	64 (5)	91 (7)	58 (2)	49 (3)
Management:						
Executives	76 (6)	65 (4)	65 (3)	93 (8)	56 (1)	47 (3)
Rangers	72 (5)	66 (30)	75 (4)	86 (5)	53 (1)	46 (2)
Foresters	78 (4)	64 (3)	65 (3)	85 (4)	56 (1)	49 (2)
Engineers	102 (5)	67 (3)	52 (4)	68 (5)	59 (1)	59 (3)
Biologists	81 (3)	67 (3)	60 (3)	86 (4)	57 (1)	51 (2)
Overall	82 (2)	65 (1)	63 (1)	85 (2)	57 (1)	50 (1)

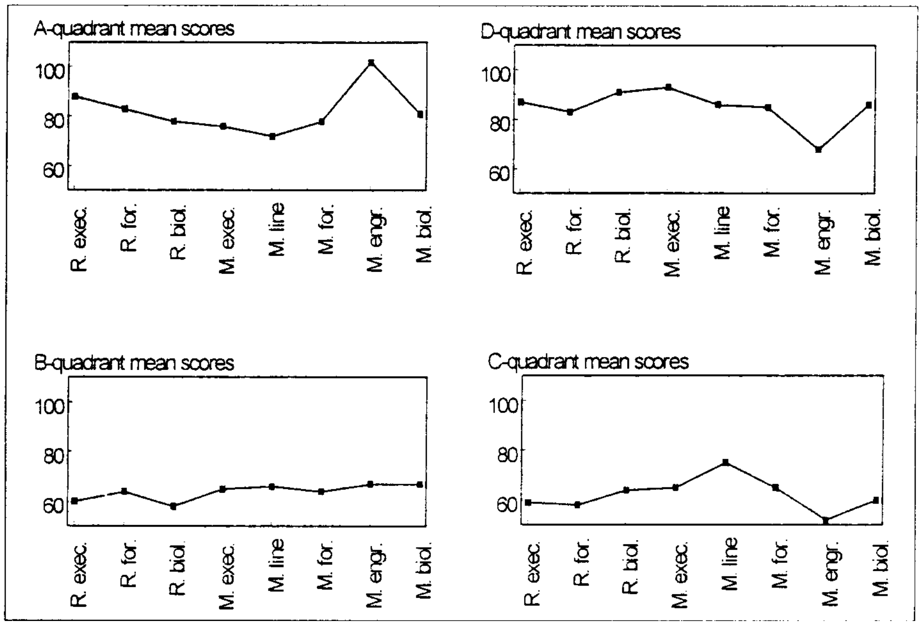

Figure 1-Profile plots of mean scores of Forest Service research (R.) and management (M.) executives (exec.), line, foresters (for.), engineers (engr.), and biologists (biol.) on the four quadrants of the Herrmann whole brain model.

A-quadrant thinking than did other occupations, except research executives, who were intermediate between the two groups. Waller-Duncan comparisons also confirmed that District Rangers had the highest average preference for C-quadrant thinking and indicated that engineers, research foresters, research executives, and management biologists had lower preferences than research biologists, management executives, and management foresters for C-quadrant thinking. Again, engineers had the lowest preference for D-quadrant thinking. Management executives had significantly higher preferences for D-quadrant thinking that other occupational groups in Waller-Duncan comparisons; but the overall test for occupational differences in preference for D-quadrant thinking was not significant ($F = 1.5$; $df = 7, 22$; $p = 0.17$). Mean ranks in the Kruskal-Wallis test exhibited the same patterns of occupational preferences for thinking styles.

Despite the common average preference for A- and D-quadrant thinking in all groups, there was considerable variation within groups as indicated by platykurtic distributions. Coefficients of variation were 15-44 percent and averaged 31 ± 1 percent ($M \pm SE$), seemingly invariant to sample size.

Four-Digit Profiles and Thinking Modes

The HBDI derived 24 different four-digit profiles from the 230 sets of scores: 2.6 percent of respondents were quadruple dominant (preferences in all four quadrants); 4.8 percent were triple dominant with an avoidance of D-quadrant thinking; 0.4 percent were triple dominant with avoidance of A-quadrant thinking; and 5.7 percent were triple dominant with use of A-quadrant thinking. Only two people (0.9 percent) had preferences for a single thinking style; 16.4 percent of the people avoided one style or another. A large majority (85.6 percent) of respondents were double dominant. The large number of profiles precluded statistical comparisons among occupations. Cases, however, tended to group at profiles representing the four thinking modes:

1221-cerebral, 37 percent; 2211-right-brain, 17 percent; 1122-left-brain, 12 percent; and 2112-2 percent, limbic. The HBDI calculates percentage preferences for the opposing modes, left-right and cerebral-limbic. There were no significant differences among occupations for left and right mode preferences (x^2 = 5.3, *df* = 7, *p* = 0.62): 123 of 230 respondents (53 percent) showed left-mode preference. All occupational groups and 83 percent of respondents reported preferences for the cerebral mode over the limbic mode. But 48 percent of District Rangers showed preferences for the limbic mode; this percentage was not sufficient to result in a significant difference in the distribution of cerebral-limbic preferences across occupations (x^2 = 11.8, *df*=7, *p*=0.11).

Key Descriptors

In total, respondents chose 21 of the 24 available key descriptors in the HBDI to describe themselves. Seven descriptors were chosen by 72 percent of the respondents: holistic (34 percent), logical (34 percent), synthesizer (28 percent), intuitive (26 percent), rational (17 percent), analytic (15 percent), and creative (11 percent). This selection was statistically significant (x^2 = 216, *df* = 154, $p < 0.01$). The distribution of respondents over the set of key descriptors confirms through simple self-description the preference for the logical (A-quadrant) and holistic (D-quadrant) thinking styles and the cerebral mode of thinking that was indicated by the summary scores for the 120 HBDI questions.

Hypotheses

My findings support the hypotheses that scientists and executives prefer the cerebral mode of thinking. The statistical results reject the hypotheses that management staff and line prefer the left-brain mode of thinking and that engineers prefer a single style (A-quadrant) of thinking. Although engineers scored significantly higher on A-quadrant thinking than other groups, their composite profile was actually triple dominant (A-B-D). The HBDI uses a cutoff of a score of 67 for a thinking style to distinguish preferred thinking styles from used thinking styles. All but one of the 95-percent confidence intervals of the mean scores (composite profile) of the eight occupational groups on the four quadrants exceeded or encompassed 67. Thus, none of the occupations, except engineering, differed significantly from a composite quadruple dominant profile. Engineers, in composite, were triple dominant, with a score of 52 (a "use" rating), with a 95-percent confidence interval of 43-60, on C-quadrant.

In summary, both research and management professionals in the Pacific Northwest see themselves as logical and holistic in their thinking. Engineers, however, tend toward the logical and analytical. District Rangers add an emphasis on interpersonal, feeling-based thinking. Despite these commonalities, there exists substantial heterogeneity in cognitive style within occupational groups and, thus, within the respective branches of the Forest Service.

Discussion

The diversity of preferences for thinking styles suggested that homogeneity of cognitive preferences within groups is not a risk factor for groupthink in the Forest Service in the Pacific Northwest. There is homogeneity among groups, but the group-level preferences emphasized both analytical and integrative thinking. This cerebral mode of thinking would be the least likely to contribute to groupthink. Groupthink involves developing a number of shared illusions (invulnerability, inherent morality, and unanimity) that lead to incomplete surveys of alternatives, failure to examine risks, and self-censorship (Janis 1983). Current Forest Service culture and cognitive preferences value analysis and critical thinking, integration of interdisciplinary and public input into broad arrays of alternatives, and a public and interdisciplinary process. Groups that emphasize B-quadrant thinking are more likely to be dogmatic. Those that emphasize C-quadrant thinking are more likely to be striving of unanimity. Emphasis on analysis without integration could lead to consideration of a narrow range of alternatives. Emphasis on integration without careful analysis of facts and logic can lead to poor decisions.

These results suggest the emphasis on interdisciplinary planning and public involvement has changed cognitive and cultural styles in the Forest Service. The Forest Service has a history of groupthink; indeed, forest management legislation in the 1960s and 1970s was a confrontation of this groupthink (Kennedy 1988). Historically, the Forest Service was conservative, hierarchical, dominated by white male foresters, and demanding of conformity (Bultena and Hendee 1972, Miller and Gale 1986, Tipple and Wellman 1989, Twight and Lyden 1989). Various natural resources professions were homogeneous subcultures (Kennedy 1985, Miller and Gale 1986). Demographics, disciplinary composition, and culture of the Forest Service (and associated professions) have changed markedly (Carroll and others 1996, Ehrenreich 1996, Mohai and Jakes 1996, Sabatier and others 1996). The Forest Service and the professional organizations to which Forest Service employees belong, however, continue to discuss the need to avoid narrow thinking, to emphasize interdisciplinary teamwork, and to respond to changing social concerns (e.g., Brown and others 1994, Bull 1994, Carrier 1995, Carroll and others 1996, Kessler 1995, Marcin 1995, Munson-McGee and Thompson 1995, Shannon 1992, Sparrowe 1995).

Implications of Heterogeneity Within Groups

I had expected to find more homogeneity within groups, especially within scientist groups, than I did, because of strong selection pressures for analytical thinking through college, graduate school, and the practice of research. I expected manager groups to show more heterogeneity than scientist groups, because managers generally have had less graduate school. But heterogeneity was similar among all the groups. It is unlikely that this heterogeneity was due to age differences as ages were similar and individual personality is relatively stable after 30 years of age (Costa and McCrae 1994). All the groups had stronger preferences for analytical and integrative thinking than for limbic mode thinking. Scientists are analytic in defining problems and processing data and integrative in discussing results and contributing to theory. Managers in the Forest Service must use both analytical and integrative thinking to resolve conflicts within interdisciplinary teams and among demands for natural resources. No group showed avoidance for planning or interpersonal relations. Ability to use B-quadrant thinking style is prerequisite to success in a large machine bureaucracy like the Forest Service. Feeling-based thinking is important to most people's personal life and for harmony in the workplace. The District Rangers, the frontline managers, showed more preference for interpersonal thinking styles than did other occupations. District Ranger profiles suggested this group of managers is indeed moving toward the 9-9 management style (Blake and Mouton 1985) that is effective in managing teams and is promoted by R-6 management training. Research executives, who may receive little management development training, exhibited preferences (on the whole) more typical of directive management styles. Thus, the heterogeneity in thinking styles within groups and homogeneity among groups may reflect (1) reconciliation of personal style with organizational needs, (2) organizational tolerance of diversity in the workforce, (3) management training programs, and (4) rapid changes in U.S. culture during the maturation of the age-group of employees sampled (Ray 1996).

Heterogeneity can contribute to the level of interpersonal conflict in the workplace and to conflict within teams, especially when teams are small (e.g., fewer than 10 people) or when large teams have little time to form. Conflict would be most likely to result from lack of communication when interpersonal differences are not recognized as a matter of personal style. Programs are in place in the Forest Service to educate employees about cultural diversity, differences in personality, and differences in thinking styles. Not all employees, however, receive all training. Training in differences in cognitive style and effective communication would be important as part of team formation. Similarly, techniques such as appreciative inquiry (Bushe and Coetzer 1995) and group sensitivity training (Faith and others 1995) could be effective when used as part of the formation of large or small interdisciplinary teams. This approach is currently used in the R-6 Management Development training program. The results of this study suggest that both research and management employees could benefit from participation in the program.

Other Sources of Conflict

Organizational climate and conflict in the workplace are a result of more than individual and group preferences for thinking styles. Although Forest Service culture changed markedly during the 1980s and 1990s, public perception of the Agency and its activities did not change significantly (Sabatier and others 1996). Forest Service line officers see the Agency as highly committed to addressing environmental and amenity issues, but staff employees see these issues as more serious than line officers do and do not believe the Agency is committed to addressing them. A majority (70 percent) of both management and staff believe the Forest Service should place more emphasis on ecological issues, and 60 to 70 percent believe the Forest Service places undue emphasis on timber programs (Mohai and Jakes 1996). Both groups felt that increased public involvement and increased emphasis on noncommodity issues were positive changes. Recently increased political pressure on the Agency was regarded negatively. Impediments to future constructive change were, in order of prevalence, Congress and competing interest groups, lack of effective leadership, loss of public support, insufficient funding, and on-the-job stress.

Thus, internal dissension in the Forest Service is, in part, a result of say-do discrepancies between the legal mandates and policies of the Forest Service and congressional line-item appropriations for, and the actions of, the Agency. Such discrepancies may be particularly important in natural resources management bureaucracies because these organizations rely on the professional skills of their frontline employees. Professional affiliation often is greater than employer affiliation (Kennedy 1985, Miller and Gale 1986). These problems can be addressed only by effective leadership that responds to both the needs and the changing culture of society and the needs and diversity of organization members (DePree 1989, Miller 1996, Mintzberg 1975).

Limitations

The target population of the study was PNW and R-6, mid-career and senior professional employees in natural resources fields. The result cannot be extrapolated beyond the Pacific Northwest. Data were archival and from a self-administered survey instrument. People may respond to such questionnaires by giving answers that (1) they think are socially desirable, (2) are indicative of how they would like to be rather than how they are, or (3) are deliberately inaccurate. All such instruments suffer from problems in interpretation. The archives were not developed through random sampling. Even though samples of executive groups were near inventories and samples of District Rangers and scientists were 35 to 60 percent of the target population, unknown biases could exist in less than complete samples. The reasons *why* some scientists did not respond to the survey are unknown, as are the reasons for some employees participating in training and others not participating. Given rapid changes in the Forest Service workforce in the Pacific Northwest in the recent past, even if the samples had been random, it would be impossible to determine if they were representative of the current workforce. Sample sizes in any particular category were small. Lumping of occupations into categories may have obscured differences among occupations and may have led to false conclusions about intragroup diversity in thinking styles. Small sample sizes precluded many of the possible analyses of inter est.

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Glossary

Acculturation-the instillation of a society's culture in an individual from infancy onward.
Amygdala-an almond-shaped mass of gray matter in the anterior temporal lobe of the brain.
Aphasia-loss of ability to articulate or comprehend spoken or written language.
Cognition-the mental process of knowing, including awareness, perception, reasoning, and judgment.
Cognitive-of or relating to cognition or thinking.
Corticolimbic-of or relating to the outer and inner layers of the cerebrum of the brain.
Groupthink-conformity to the values and ethics of a group.
Heterogeneity-dissimilarity in elements or parts.
Homogeneity-uniformity of structure and composition.
Kurtosis-the extent to which a unimodal frequency curve is peaked; i.e., the relative steepness of ascent in the neighborhood of the mode. Anormal distribution has a moment ratio value of three (bell-shaped), Platykurtic distributions <3 (flat-topped), and leptokurtic >3 (narrow-topped).
Limbic-of or relating to the inner cortex of the brain.
Personality-the collective character, behavioral, temperamental, emotional, and mental traits of a person.
Promax rotation-a specific approach to factor analysis, which seeks to extract a few factors from many variables to better explain complex relations among the variables of interest.
Psychometric-of or relating to the measurement of psychological variables, such as intelligence, aptitude, and personality traits.
Skewness-asymmetry in a frequency distribution; negative skewness refers to a long tail of low values, positive to a long tail of high values.
Socialization-the process of making an individual fit for companionship with others and amenable to the needs of society.
Triune brain-a model of human brain development based on the superimposition of the reptilian, old mammal, and new mammal brains to form the brainstem and midbrain, the limbic system, and the cerebral cortex.
Visuospatial-of or relating to visual perception of spatial relations among objects.