

Macroergonomics: Analysis and design of work systems

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Abstract

Attending to the larger system components such as organizational design and management is not novel for ergonomists. In Europe, there has been a strong tradition to investigate ergonomic problems within a holistic, systems context. “Macroergonomics” builds upon this tradition by providing specific methods and tools that yield large-scale results. It is believed that meaningful and large-scale results are needed in today’s competitive and turbulent work environments. Macroergonomics is defined, its history is uncovered and focus is given to a key methodology, macroergonomic analysis and design. Case studies are used to validate the method and illustrate that performance results in the 60–90% range can be expected.

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1. Introduction

1.1. History of work systems

Macroergonomics is the design of work systems which focuses on organization-system interaction. Design in general, and work system design in particular, is influenced by theory. Therefore, work system design has been influenced by the prevailing organizational theoretical perspectives. The history of theoretical perspectives on organization includes a forked road, with one path characterized by the Classical School and the other the Human Relations School (Weisbord, 1991). From the Classical School of organizational thought, dating back to the early 1900s, were derived such common organizational innovations as supervision, hierarchy, reward systems and span of control. From the Human Relations School, dating to the 1950s, are derived organizational elements such as teams and motivation. In a sense, the Gilbreth’s time and motion approach to work design was a human relations augmentation of Taylor’s classical time study approach

to the increased efficiency of work. In the 1970s and into the 1980s, there seemed to be an automation thrust, or a strong bias in industry to automate, simply because the means and technology to do so existed. As Unterweger (1988) reported, machine-centered industrial designers pushed the “factory of the future”, a computer-integrated, workerless system, to eliminate the costly and disruptive human factor (p. 13). At an aircraft bearings company, a move to adopt automated inspection systems was stifled when ergonomists performed a head-to-head comparison to manual inspection and the automated alternative fell short of expectations. The author then assisted in the development of training and job aids to increase the reliability of the human inspectors (Kleiner and Drury, 1993). In another example from the author’s experience, a large, well-known telecommunications firm purchased dozens of expensive semi-automated printed circuit board (PCB) machines because they were available on the market. These had not been tested by ergonomists and when put to the test, were only somewhat effective for a small subset of PCB defects (Drury and Kleiner, 1984).

The “automated factory” and other industrial visions seemed to bolster technology dissemination or what Unterweger called “machine-driven” design approaches.

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On the other hand, in the 1980s, some organizations took Total Quality Management and the team movement to an extreme, creating a human-driven culture without appropriate attention to technology and the methods or operations associated with work. Even today, organizations appear to be driven by either Classical thinking, Human Relations thinking or by an attempt to integrate the two. As [Smith and Sainfort's \(1989\)](#) balance theory suggested, the macroergonomics approach offers a balance between the Classical and Human Relations approaches.

1.2. The need for the macroergonomic approach

In the 1950s, the ergonomics field began in response to human–machine mismatches, especially in aviation ([Chapanis, 1965](#)). The 21st century is evidenced by unprecedented technology and complexity and in part this has produced renewed work system design challenges. For example, in healthcare, nurses and other staff are routinely working 12 h shifts. Healthcare organizational structures have changed, mismatches exist between human staff and medical technology and the drive to reduce cost has created efficiencies at the expense of effectiveness and human personnel well-being. Thus, medical errors and the associated human and financial costs are of great concern in this industry. In the military, “friendly fire” incidents are making the headlines. Manufacturing has been rapidly migrating to such countries as China. Aviation is also challenged by reduced demand and the need to reduce costs. In the US construction industry, workers are experiencing safety and health incidents at an alarming rate. It is not yet clear why other countries have lower incidence rates, nor why in the US certain ethnic sub-groups experience more incidents than others. However, as recognized in Europe, it is suspected that a combination of managerial, design and cultural factors will be implicated ([Haslam et al., 2005](#)). The service sector is plagued by work design issues and human–computer interaction needs are extensive. Virtually, every industry is challenged and these needs go beyond the human–machine interface level of solution.

These examples and others suggest the need for a large system approach as offered by macroergonomics. Specifically, [Hendrick and Kleiner \(2001\)](#) identified three common design pitfalls to work system design that create the need for a macroergonomic approach: (1) technology-driven design; (2) a leftover approach to design and (3) inattention to the socio-technical characteristics of work systems. It appears that society's advances in information technology and communication systems have not reduced the prevalence of these pitfalls. Coupled with the need to attend to the larger system is the need to yield significant results. In this context, it appears that ergonomists like others need to cost-justify

their interventions ([Beevis and Slade, 2005](#)). Macroergonomics may be a way to aid this pursuit.

1.3. The emergence of macroergonomics

In the late 1970s, the Human Factors Society commissioned a “Futures Study”. This committee identified several trends predicted to influence ergonomics over the following 20 years. These trends included: increased technology; increased diversity of demographics; more permissive values changes; increased world competition; and a failure of microergonomics to achieve relevant and sufficient results ([Hendrick, 1986](#); [Hendrick and Kleiner, 2001](#)). While this study formally led to the creation of the so-called “macroergonomics” movement in the US, [Hendrick \(1991\)](#) indicated that there were informal precursors of the formalized macroergonomics sub-discipline in both the US and the UK. Mac Parsons in the US (e.g. [Parsons, 1972](#)) and Nigel Corlett in the UK (e.g. professorial address at the University of Birmingham in 1967—[Drury, 2005](#)) were credited with taking the large system perspective in their ergonomics work. Others, such as W.T. Singleton, have also warned against compartmentalizing ergonomics. For example, he has suggested that when measuring the human at work, neither the physiological nor the psychological approach is sufficient ([Singleton, 1973](#)). As the “academic grandson” of Nigel Corlett, the author is compelled to agree that philosophically, and to some extent methodologically, systems ergonomics as practiced in Europe for 50 years accounts for much of the philosophy behind macroergonomics. Its underlying theoretical framework, socio-technical systems (STSs), is also clearly a European (UK) innovation.

Macroergonomics, the author believes, has at least two value-adding contributions beyond those of systems ergonomics (although the author often uses these terms as synonyms). Firstly, building upon systems ergonomics, macroergonomics provides specific and refined methodologies and tools linked to an underlying theory for work system analysis and design such as Macroergonomic Analysis of Structure and macroergonomic analysis and design (MEAD) ([Hendrick and Kleiner, 2001](#)). Secondly, the term “macroergonomics” has become a rallying point for US-based researchers and practitioners to get involved in the systems ergonomics movement. For some reason, the term “systems ergonomics” has not taken off in the US, much like the term “human factors” emerged because Europe's “ergonomics” had not taken root.

The organizational design and management (ODAM) technical group was formed within the Human Factors Society in 1981. In 1984, the ODA technical committee of the IEA was formed. This was also the year of the first biennial symposium of ODA. The

need for traditional ergonomics has been and continues to be pervasive. As systems become technologically more complex, if anything this need continues to expand. However, with the need to understand human capabilities and limitations, also comes a need to attend to the larger system. Interface design is necessary but insufficient in most contexts. Systems are too complex, environments are too turbulent and organizations are too competitive to justify a focus on interface design alone. Technology and humans interact and they do so within an organizational context. Organizations operate within larger environmental systems and therefore it behooves the ergonomist to know enough about the larger system factors so that their ergonomics success can be maximized.

1.4. Theoretical underpinnings

Ironically, macroergonomics is one of the few sub-disciplines of ergonomics that has a clear, ever-present, theoretical contextual framework. STS theory has provided inspiration and methodological guidance since the informal foundation of macroergonomics. STS emerged from the Tavistock Institute and is based upon open systems theory from the biological sciences. Co-founder, Fred Emery was a biologist and co-founder Eric Trist was a psychologist (Emery and Trist, 1965, 1978). The Longwall Mining experiment in the UK is the iconic example of the movement. The automated longwall method replaced the more manual shortwall method in coal mining. The shortwall method was characterized by a congruence among psychosocial, cultural, task and work system design. The longwall method was intended to be more efficient, with shifts of 10–20 workers, narrow tasks, limited interaction, interdependence across shifts, and incongruence among psychosocial, cultural, task and work system design. The predicted improvement in performance was not observed. Instead, low production, absenteeism, and inter-group conflict and competition became common (DeGreene, 1973). A hybrid approach retained the work design of the shortwall method and incorporated the new technology. Performance dramatically improved. The lesson of Tavistock was that work systems can be exemplified by varying levels of automation with the same organizational design. At its core, STS provides the perspective that a system is inextricably affected by its environment and that there are several sub-systems involved in effective work system design and redesign.

1.5. Macroergonomics defined

Macroergonomics integrates principles and perspectives from industrial, work and organizational psychology. Macroergonomics is the study of work systems (Hendrick and Kleiner, 2001), where a work system

comprises two or more people working together (i.e. personnel sub-system), interacting with technology (i.e. technological sub-system) within an organizational system that is characterized by an internal environment (both physical and cultural). The basic work system is illustrated in Fig. 1.

How well technological and personnel sub-systems are designed with respect to one another and the demands of the external environment determine how effective the work system will be (Pasmore, 1988). Organizational design is focused upon the design of three core dimensions: complexity, formalization and centralization (Hendrick and Kleiner, 2001). Complexity has two components—differentiation and integration. Differentiation is focused on the segmentation of the organization. Integration is focused on linking the segments together with coordinating mechanisms. Formalization is defined in terms of the degree of standardization. Centralization is concerned with decision-making and the extent to which authority is concentrated within a few individuals. The basic precept is that the organizational design configurations begin at the macro, organizational level. Then, the design configuration is carried down to the microlevel. This open system operates within a dynamic and sometimes turbulent external environment. The personnel sub-system then is defined by those who do the work. The technological sub-system is defined by how the work is accomplished. The environmental sub-system in actuality is composed by several sub-systems. According to Pasmore (1988), organizations view their environments as sources of inspiration or provocation. The former is characterized by organizations aggressively controlling their environments. They expect turbulence and are energized by the possibility of influencing their environments. The latter is a reactive, passive philosophical approach to the environment. Here, if possible, the environment is ignored for as long as possible. If it becomes necessary, the organization will react to stimuli from the environment.

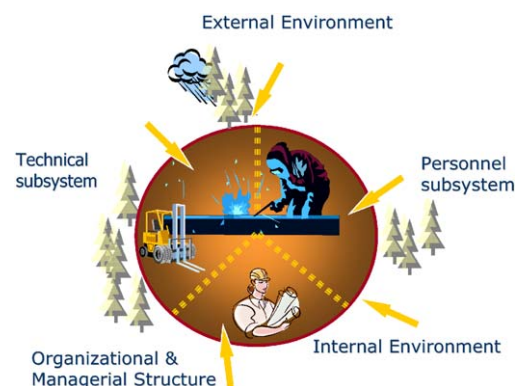


Fig. 1. Basic work system model.

Macroergonomics is top-down in that it begins with the relevant STS variables in terms of their implications for the design of the overall structure of the work system and related processes (Hendrick, 1995), but through participatory ergonomics it is also bottom-up (Hendrick and Kleiner, 2001). Once these factors are assessed, organizational and job design as well as ergonomics prescriptions are generated. The large-scale improvements indicative of macroergonomic interventions are achieved through an approach to design which considers four interrelated sub-systems as illustrated in Fig. 1. As illustrated by Mulholland et al. (2005), top-down and bottom-up intervention is difficult. They suggest taking into account the differences in perceptions between teams and individuals lower in the hierarchy and those in upper management when developing and deploying initiatives within the organization.

2. Methods

Macroergonomics, like other sub-disciplines of ergonomics, possesses a combination of borrowed and unique methods and tools. Typically, there is a clear connection to the previously mentioned theoretical assumptions which present macroergonomics as a somewhat unique sub-discipline. One example of such a methodology is MEAD. This 10-step methodology is used to evaluate and design work systems (Hendrick and Kleiner, 2001). MEAD is based in part upon the contributions of Emery and Trist (1978), Taylor and Felton (1993) and Clegg et al. (1989). The methodology builds upon STSs theory. There are 10 steps in MEAD (see Table 1) that are briefly described below:

2.1. Step 1: Scanning the environmental and organizational sub-systems

Since the external environment, operating under the principle of joint causation, may be the most influential sub-system in determining whether the STS will be successful, it is important to pursue what is called “joint

optimization” between the technological and personnel sub-systems. To do so requires a proper scan of the system and the environment.

When scanning the system it is useful to determine the nature and extent of any variance between the organization’s public and private identities. To accomplish this, the formal company statements about mission (i.e. purpose), vision and principles are assessed. In terms of performance, it is instructive to investigate professed versus actual performance in multi-criteria terms. The organization’s mission is typically detailed in systems terms (i.e. inputs, outputs, processes, suppliers, customers, internal controls and feedback mechanisms). The system scan also establishes initial boundaries of the work system. As described by Emery and Trist (1978), there are throughput, territorial, social and time boundaries to consider.

What lies outside the boundaries identified during the system scan comprises the external environment. In the environmental scan, the organization’s sub-environments and the respective owners or stakeholders of these sub-environments are identified. Stakeholder expectations are evaluated against system expectations. Variances are evaluated to determine design constraints and opportunities for change. Often, any gaps between work system and environmental expectations are gaps of perception or communication which can be mitigated through design or training.

It is appropriate to develop organizational design hypotheses based upon the environmental and system scans. By referring to the empirical models of the external environment (Hendrick and Kleiner, 2001), optimal levels of complexity (both differentiation and integration), centralization and formalization can be hypothesized.

2.2. Step 2: Defining production system type and setting performance expectations

The identification of the work system’s production type can help determine optimal levels of complexity, centralization and formalization. The system scan performed in the first step should help. In this context, key performance criteria are identified. This requires a determination of performance drivers for products and services. Standardized performance criteria guide the selection of specific measures which relate to different parts of the work process (Kleiner, 1997). Measures can be subjective, as in the case of self-reports, or measures can be objective taken directly from performance.

Sink and Tuttle (1989) suggested that organizational performance can be measured or assessed using seven performance criteria or clusters of measures: efficiency, effectiveness, productivity, quality, quality of worklife, innovation, and profitability or budgetability. Within a given performance criterion, specific measures can be

Table 1
MEAD 10-step methodology

1. Scanning the environmental and organizational design sub-system
2. Defining production system type and setting performance expectations
3. Defining unit operations and work process
4. Identifying variances
5. Creating the variance matrix
6. Creating the key variance control table and role network
7. Performing function allocation and joint design
8. Understanding roles and responsibilities perceptions
9. Designing/redesigning support sub-systems and interfaces
10. Implementing, iterating and improving

defined. Data sources for each measure can be subjective or objective. Kleiner (1997) added a criterion of flexibility.

Once the type of production system has been identified and the empirical production models reviewed, the organizational design hypotheses generated in the previous step should be supported or modified until the personnel sub-system can be thoroughly analyzed as well. In terms of function allocation, requirements specifications can be developed, including traditional ergonomic requirements. Also included are system design preferences for complexity, centralization and formalization. From Clegg et al. (1989) comes the recommendation to use scenarios that present alternative allocations and associated costs and benefits.

2.3. Step 3: Defining unit operations and work process

Unit operations are defined as groupings of conversion steps that together form a complete piece of work and are bounded from other steps by territorial, technological or temporal boundaries (Emery and Trist, 1978). Unit operations can often be identified by their own distinctive sub-product and typically employ 3–15 workers. They can also be identified by natural breaks in the process (i.e. boundaries determined by state changes (transformation) or by changes in the raw material's form or location (input) or the storage of material. For each unit operation or department, the purpose/objectives, inputs, transformations and outputs can be defined. If the technology is complex, additional segmentation (e.g. horizontal differentiation) may be necessary.

The process flow should be flow charted, including material flows, workstations and physical as well as informal or imagined boundaries. In most production systems, the output of one step is the input of the next. In non-linear systems, such as many service or knowledge work environments, steps may occur in parallel or may be recursive. Unit operations should be identified. Also identified are the functions and sub-functions (i.e. tasks) of the system (Clegg et al., 1989). The purpose of this step is to assess improvement opportunities and potential coordination problems. Identifying the work flow before continuing with detailed task analysis can provide a meaningful context in which to analyze tasks. Once the flow is charted, the ergonomist can proceed with a task analysis for the work process functions and tasks.

2.4. Step 4: Identifying variances

A variance is an unexpected or unwanted deviation from standard operating conditions, specifications or norms (Emery and Trist, 1978). STS suggests distinguishing between input and throughput variances. The

identification of variances at the process level as well as the task level can provide important contextual information for job and task redesign to improve safety and quality performance. By flowcharting the current process and detailing through a task analysis, variances can be identified.

2.5. Step 5: Creating the variance matrix

Key variances are those variances which significantly impact performance criteria and/or may interact with other variances thereby having a compound effect. The purpose of this step is to understand the interrelationships among variances. The variances should be listed in the order in which they occur down the Y-axis and the horizontal X-axis. The unit operations (groupings) can be indicated and each column represents a single variance. The ergonomist can read down each column to see if this variance causes other variances. Each cell then represents the relationship between two variances. An empty cell implies two variances are unrelated. The analyst or team can also estimate the severity of variances by using a Likert-type rating scale. Severity would be determined on the basis of whether a variance or combination of variances significantly affect performance. This should help identify key variances.

A variance is considered key then if it significantly affects quantity of production, quality of production, operating costs (utilities, raw material, overtime, etc.), social costs (dissatisfaction, safety, etc.), or if it has numerous relationships with other variances. Typically, only 10–20% of the variances are significant determinants of the quality, quantity or cost of product.

2.6. Step 6: Creating the Key Variance Control Table and role network

This step is performed to learn how existing variances are controlled and whether personnel responsible for variance control require additional intervention. The Key Variance Control Table includes: the unit operation in which variance is controlled or corrected; who is responsible; what control activities are currently undertaken; what interfaces, tools or technologies are needed to support control; and what communication, information, special skills or knowledge are needed to support control.

While a job is defined by the formal job description, which is a contract or agreement between the individual and the organization, a work role comprises the behaviors of a person occupying a position or job in relation to other people. These role behaviors result from actions and expectations of a number of people in a role set—the people who are sending expectations and reinforcement to the role occupant. Role analysis addresses the interacts among members in the network

and the effectiveness of these relationships. This relates to technical production and is important because it determines level of work system flexibility. In a role network, first the role responsible for controlling key variances is identified. There is typically a single role, without which the system could not function and variances could not be controlled.

With the focal role identified, additional roles can be defined in relation to the focal role. Based upon the frequency and importance of a given relationship or interaction, line length can be varied, where a shorter line represents more or closer interactions. Finally, arrows can be added to indicate the nature of the communication in the interaction. A one-way arrow indicates one-way communication and a two-headed arrow suggests two-way interaction. Two one-way arrows in opposite directions indicate asynchronous (different time) communication patterns. To show the content of the interactions between the focal role and other roles, functional requirements labels are used to indicate: goal of controlling variances; adaptation to short-term fluctuations; integration of activities to manage internal conflicts and promote smooth interactions among people and tasks; and long-term development of knowledge, skills and motivation in workers. Also the organizational nature of particular relationships are identified as vertical hierarchy; equal or peer; cross-boundary; outside; or non-social.

The relationships in a role network are then evaluated. Internal and external customers of roles can be interviewed or surveyed for their perceptions of role effectiveness. Also, the organizational design hypotheses can be tested against the detailed analysis of variance and variance control. The role analysis and variance control table may suggest, e.g. a need to increase or decrease formalization or centralization. If procedures are recommended to help control variances, this increased formalization should be evaluated against the more general organizational design preferences suggested by the environmental and production system analyses.

2.7. Step 7: Performing function allocation and joint design

Before allocating function, it is helpful to review the environmental scan data to check for any sub-environment constraints (e.g. political, financial, etc.) before making any mandatory allocations (Clegg et al., 1989). Next, provisional allocations can be made to the human(s), machine(s), both or neither. In the latter case, a return to developing requirements may be appropriate using the following criteria: technical feasibility; health and safety; operational requirements (i.e. physical, informational, performance); and function characteristics (i.e. criticality, unpredictability, psychological).

Technical changes are made to control or prevent key variances. Human-centered design of the following may be needed to support operators as they attempt to prevent or control key variances: interfaces; information systems to provide feedback; job aids; process control tools; more flexible technology; redesign work station or handling system; or integrating mechanisms.

After considering human-centered system changes in the previous step, it is time to support the worker directly by addressing knowledge and/or skill requirements of key variances and any selection issues which may be apparent. In the variance control table, we identified who controls variances and the tasks performed to control these variances. At this step, personnel system changes are recommended to prevent or control key variances. This may entail specific skill or knowledge sets that can be acquired through technical training, formal courses, workshops or distance learning.

Organizational design hypotheses have been generated and iteratively adjusted as new analyses are performed. It is time to take the specifications for organizational design levels of complexity, centralization and formalization and to produce specific structures. Depending upon the level of work system process analysis, this may require design/redesign at the organizational level or at the group/team level or at both levels.

2.8. Step 8: Understanding roles and responsibilities perceptions

It is important to identify how workers perceive their roles. Role occupants can participate in the identification of their perceptions of their roles. Using the previously constructed table, expected roles, perceived roles and variances can be identified. Variances can be controlled via training and selection as well as through technology. Any variation between the two role networks can be reduced through participatory ergonomics, training, communication, interface design or tool design.

2.9. Step 9: Designing/redesigning support sub-systems and interfaces

The goal of this step is to determine the extent to which a given support system impacts the socio-technical production system; to determine the nature of the variance; determine the extent to which the variance is controlled; and to determine the extent to which tasks should be taken into account in redesign of operating roles in the supporting sub-system units. According to the Clegg et al. (1989) method of function allocation, individual and cumulative allocations made on a provisional basis earlier can be further evaluated

against: requirements specifications (including the scenarios developed earlier); resources available at the time of implementation (including human and financial); and the sum total outcome. In addition to a check of function allocation, interfaces among sub-systems should be checked and redesigned at this juncture.

Especially at the team and individual levels of work, the internal physical environment should be ergonomically adjusted if necessary to promote human well-being, safety and/or effectiveness. There may be physical environmental changes that will promote improvement as well. These changes might include changes to temperature, lighting, humidity, noise control/hearing protection, etc.

2.10. Step 10: Implementing, iterating and improving

Usually, the macroergonomics team will not have the authority to implement the changes suggested by the analysis, and proposals with recommendations for change may be required for presentation to management. Based upon the proposal feedback, modifications to the proposal may be necessitated which will require a return to the earlier step which represents a challenged assumption or design.

As illustrated in Fig. 2, this process is iterative. For continuous improvement (i.e. the STS principle of

“incompletion”), evaluations may suggest a return to an earlier step in the process for renewed partial or full redesign. Once the proposal for change is accepted by management and implementation begins, regular updates should be conducted. To complement the weekly formative evaluations performed by the implementation team, semi-annual formative evaluations should be performed by an objective outside party. This evaluation should be presented to the implementation team and a dialog about expectations and progress-to-date should be performed.

3. Results

The goal of macroergonomics is optimal ergonomics compatibility (Hendrick and Kleiner, 2001). Field and laboratory results confirm the effectiveness of macroergonomics. While laboratory studies tend to focus on advancing STSs theory or computer-supported collaborative work systems knowledge, field interventions have tended to pursue large-scale organizational change (Kleiner, 1996). In this regard, Hendrick (1997) reported that macroergonomics interventions achieve 60–90% performance improvement (e.g. productivity or quality) while traditional ergonomics results are in the 10–20% range. Kleiner and Drury (1999) reviewed several cases

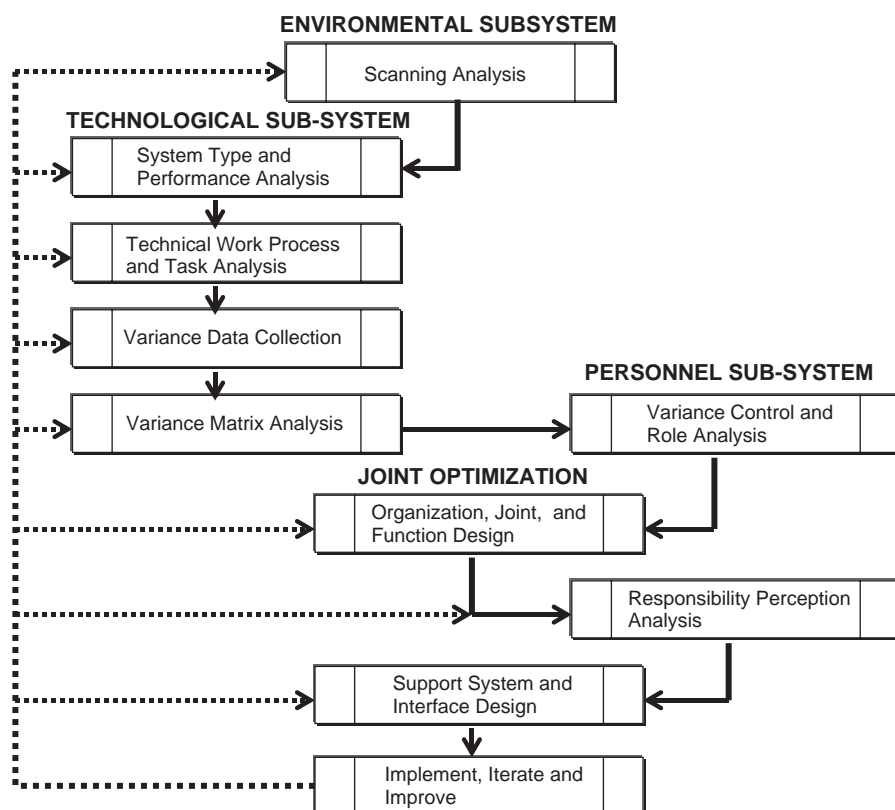


Fig. 2. Graphical representation of MEAD (adapted from Hendrick and Kleiner, 2001).

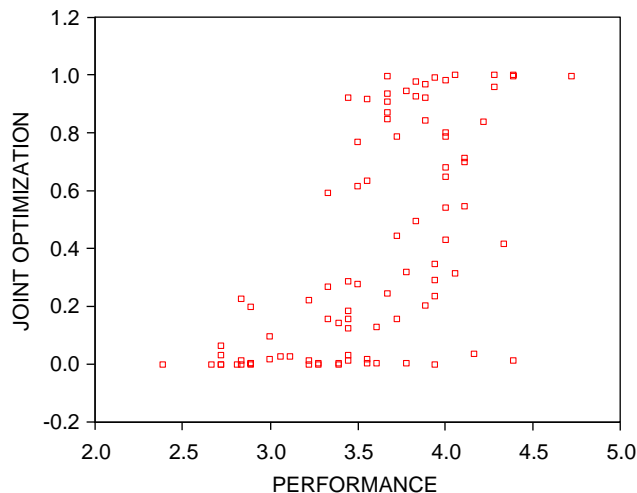


Fig. 3. Relationship between joint optimization and performance (Grenville, 1997).

across educational, industrial and governmental sectors. As mentioned previously, the ergonomist will not always have the opportunity to implement a comprehensive methodology such as MEAD. However, key components of the methodology can be linked to efficient (e.g. 6 months–1 year) and effective (e.g. 50% performance increase or more) turnarounds at six (6) industrial companies in the mid-80s. These companies collectively produced a diverse set of products including automotive components, food and aircraft components. In the 90s, large-scale change was implemented at governmental sites to include among other objectives, a safety culture. Fig. 3 illustrates the results from a field study performed in Canada that quantified the relationship between the STS construct of joint optimization and departmental performance (Grenville, 1997). Using the survey method, departmental managers across several firms rated the performance of their departments and estimated the ratio of management of the technological sub-system to the personnel sub-system. This was the first known attempt to quantify the STS construct of “joint optimization” in terms of demonstrating a relationship between joint optimization and performance and in terms of establishing a ratio of personnel and technological focus. In this study, managers’ spending their time 60–70% on the technological sub-system and 30–40% on the personnel sub-system was optimal.

Finally, as mentioned earlier, the full methodology is being used currently in the construction and healthcare industries.

4. Future needs

Macroergonomics builds upon the strong, 50-year tradition of systems ergonomics in Europe. The sub-

discipline and perspective of macroergonomics is in need of recognition within the professional field, especially in the US. The interrelationship and integration between ergonomics and organizational design are better understood and appreciated internationally. Ironically, macroergonomics offers the field of ergonomics a solution to the desperate need for performance measurement and evaluation of large-scale system results. The focus on integration and organizational design presents macroergonomics as a relevant branch of ergonomics. Whether trained as a specialist in macroergonomics or as a “traditional” ergonomist with a systems ergonomics or macroergonomic perspective, the ergonomist and therefore his/her clients could benefit greatly from this perspective.

At a practical level, a question often asked is when should macroergonomics be deployed, especially since ergonomists recognize that clients are often unlikely to implement all of the ergonomists’ recommendations due to limitations of time, cost, expertise and motivation (Whysall et al., 2004)? There are times when a comprehensive methodology can be implemented. For example, under a grant from the National Institute of Occupational Safety and Health the author and his colleagues are currently using macroergonomics methodology to help reduce accidents, injuries and fatalities experienced by the US construction industry. Industry does tend to be problem-driven but ironically, even though they tend to be problem-driven, they are often uninterested in evaluation of interventions and solutions (Whysall et al., 2004). In the author’s experience, there are examples when industry has contracted for a broad assessment of a problem, and in such cases methodologies such as MEAD can be deployed. In cases when the client has contracted for a specific solution to a specific problem, it is incumbent upon the ergonomist to recommend a more comprehensive assessment or a broader array of solutions if the problem is sufficiently complex. At a minimum (consistent with the tradition of systems ergonomics), the consultant should have a “large system view”, even when tackling a specific problem. As discovered by Whysall et al. (2004), consultants tend to recommend a range of solutions due to the complexity of many problems. Finally, it should be recognized that one of the core justifications for macroergonomics is the need for major performance improvement instead of the traditional incremental improvement. Just as ergonomists can do a better job convincing clients that evaluation is important, ergonomists can also do a better job when they propose projects. The old adage, “you get what you pay for” is applicable. Comprehensive methodologies such as MEAD are more likely to yield large-scale results and “traditional” ergonomic interventions are more likely to result in incremental performance improvements.

5. Conclusions

Macroergonomics offers methods and tools within the context of a large system perspective. Whether the pursuit is to become a specialist or generalist, the ergonomist can be well served by acquiring a background in systems or macroergonomics. Macroergonomics is concerned with the research, development and application of organization/machine interface technology (Hendrick, 1995). It is the “third generation” of ergonomics, where the first generation was characterized by human/machine interface technology, and the second generation by user/interface technology (Hendrick, 1997). Through its own methods and tools, macroergonomics attempts to achieve a fully harmonized work system at both the macro- and microergonomic level (Hendrick, 1995).

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