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**The analysis and design of mental
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The analysis and design of mental information work: a method based on the action facilitation approach

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Key words: *Mental information work, Work analysis, Work design*

1. Introduction

One of the traditional problems in the field of Work and Organizational Psychology is the design and improvement of work. Several approaches and methods have been developed for dealing with this problem (Wall & Martin, 1987). Developments in the ecology of work, especially the growth of the service sector and the increasing spread of information technology seem to have changed the nature work in such a way (Roe et al., 1992; 1993) that one must doubt whether formerly developed methods for analyzing and designing work are still applicable. E.g. one of the changes is the increased 'mentalization' of work activities, that has been invoked by new information technologies (NIT). By this we mean the reduction of physical components in work activity in favour of an increase of mental operations. Related to this is a change of work objects: tangible, material objects are being replaced by information objects and information systems in a great number of cases. Our assumption is that a new class of work, designated as 'Mental Information Work' or MIW, has emerged, defined as work with information and information objects in which mental activities predominate (Roe & Meijer, 1990). At the present time there exists little systematic knowledge on MIW and higher mental processes in work activity. And there are hardly any methods that are specifically geared to this type of work (Wall et al., 1990). One could say that the empirical context in which existing design theories for work have been developed, tested and in which they are valid, does not exist any more for these new kinds of work (cf. Webster & Starbuck, 1988). Work and Organizational psychology, therefore, is confronted with a 'theoretical vacuum' (Wall et al., 1990) that should be filled by further research on MIW. But simultaneously, the need of industry for new methods that can be successfully used in settings that become more and more prevalent, and are of growing

importance for economic performance, should be met by testing existing methods and developing new ones.

2. Objective and approach

This paper describes a project that aims at the development of a Dutch method for analyzing, evaluating and (re)designing MIW from the perspective of enhancing workers' psychological well-being. The method is based on 'Action Theory' (Hacker, 1978, 1986, cf. Frese & Zapf, 1993), and more in particular on the so-called 'Action Facilitation Approach' (Roe, 1984, 1988). Ideas from the TBS-GA (Rudolph e.a., 1987), the RHIA (Leitner et al, 1987), and work analysis methodology of Matern (1984) have been incorporated as well. The key assumption of Action Theory is that human activity consists of goal-directed behaviour, regulated by means of cognitive plans that are designed by the worker himself. Actions are supposed to be controlled by hierarchically structured regulatory processes and feedback loops. It is assumed that workers tend to maximize the efficiency (i.e. the result obtained relative to the effort spent) of their actions, provided that they are given sufficient autonomy and proper means. Critical for work design on the basis of Action Theory is the assessment of regulational processes (in terms of levels and variety), because of their predictive value for long term well-being and personality development.

The approach of Action Facilitation (AF) specifies a number of principles for supporting the worker in his search for efficiency. Although originally developed for the (re)design of interfaces for computerized work tools, it has been generalized to the (re)design of work in general, so-called 'within-job design' (Roe & Meijer, 1990). AF looks for support in every phase of an action: i.e. orientation, design of action programmes (planning), decision making, execution of action, supervisory activity and use of feedback. It thereby supports the regulation of the work activity, and at the same time the regulation of the worker's psychophysiological state and work load. In addition AF tries to avoid unnecessary negative affective outcomes of work, by demanding that an action should be allowed to run its course, thus preventing its interruption by outside events that do not belong to the task.

The methodological basis for our method has been provided by the 'Tätigkeits Bewertungs System für Geistige Arbeit'(TBS-GA), an objective work centred expert method especially developed for mental work. This method aims at enhancing human growth in work, by analyzing objective characteristics of the work, including the social and technical context, to assess mental demands and levels of psychological regulation processes. Among the criteria for evaluation and design are the enlargement of control and responsibility, complexity and completeness of the task, social interaction and feedback. Apart from describing the actual situation (in 60 scales and a profile of work characteristics), the procedures lead to concrete guidelines for re-design. Whereas the TBS-GA is very comprehensive with respect to 'architectural' factors, it does not explicitly recognize this 'within-job' characteristics. In this respect our method is different, as it relies on the Action Facilitation Approach and the notion of 'Regulationshindernisse' from the RHIA. This notion refers to a wide variety of factors in the work situation that can hinder work activity, while AF concentrates on factors explicitly related to the conscious, goal-directed aspects of the action itself.

3. Typical problems

In our project we were faced with several theoretical and methodological problems, some of which are typical for the specific domain of MIW. Three of these problems will be discussed here. They related to: the lack of direct access to mental activity, the complexity of the interaction between the worker and the environment, and the difficulty of establishing norms for 'good' work.

1. The accessibility of mental activity for analysis

To some degree the problem of accessibility of behaviour and regulation pertains to the analysis of every type of work. An analysis focusing on regulational processes as demanded by Action Theory suffers from the difficulty that these processes cannot be observed directly, neither in manual physical labour nor in mental work. As they depend on the competencies and work strategies of the individual worker, these processes cannot be deduced or inferred from recorded data solely (Matern, 1984). One has to rely on a combination of observations and information provided by the worker. In the case of MIW the problem of access is more serious, since those parts of the workers' activity that involve

the muscular apparatus and become manifest in concurrent transformations of physical objects are less prevalent and hence offer less opportunity for observation. We deal with these problems in the following way. First, we opt for a broad set of data collection methods, the results of which will be carefully integrated. Secondly, we include in the analysis a wide range of external factors that give rise to mental work activity and affects its progress, like e.g.: conditions and constraints, objects and results as materialized components of mental processes, tools and materials, time arrangements, interruptions etc. (cf. Facaoaru & Frieling, 1986). Thirdly, we choose for analysts with expertise in the domain of the analyses, and ask them to acquire additional knowledge required by the work. We follow the suggestion by Resch (1989) to teach the analyst the basic knowledge, but we supplement this with teaching of analysts by the workers themselves.

2. Person-task interaction

The second problem is common to all activity-oriented methods of analysis. The essence of the problem is the difficulty of separating situational and personal factors and their reciprocal and partly simultaneous influences during the unique process of interaction that takes place when work is being performed. The analyst is typically confronted with a 'blurred' situation that should be 'cut' into time episodes, situational states and human operations with the help of analytical tools. In the case of MIW the task of the analyst seems to be more hard, because of the reduced accessibility of mental work. Compared to other types of work there is less correspondence between occurrences in the outer world and mental activities at the side of the worker. In fact, a transformation of the external work object may follow only after a complex series of mental states and operations have taken place that may remain hidden for the analyst. This seems especially true for jobs at higher professional levels. We try to find a solution for this problem by using a model of the work activity, as an analytic tool. This model should be a process model, that depicts the activity in terms of time and strategy, rather than as a structural model (such as e.g. used in the literature on stress) that lists components that are supposedly invariant across people in particular job categories.

3. Norms for evaluating work

Design is the result of a process of optimisation with respect to a number of criteria that provide an operational representation of the design goal. Ideally, criteria can be used for evaluating work as it exists, as well as for designing work. Norms are specified values, in

terms of fixed measurable units, of these criteria. Norms can represent either a base-line (minimum norm), an 'optimal level', or a 'maximum' level of the criterion-variable. Typical for Action Theory is that design criteria do not relate to characteristics of the job per se, but rather to the activity of the worker evoked by the job, and the outcomes resulting from the activity. While the design focuses on tasks and environment, to be sure, it is evaluated by looking at work behaviour and the effects on the worker. The criteria similarly relate to (1) aspects of activity regulation, such as 'completeness of activities', 'action facilitation' and 'absence of regulation hindrances'; (2) personal outcomes of the work, such as 'endurance' and 'personal growth' (Hacker, 1986), and more generally, well-being. The use of outcome variables poses a problem because of the indirectness of the effect, especially in the case of conditions that lack a material substrate. While physical conditions may have a direct, dosage dependent impact on the individual, immaterial conditions typically do not. The connection between the working conditions and the outcomes is therefore, harder to establish. Moreover people tend to compensate for aversive or complicated work characteristics by means of diverse coping strategies and effort. This creates a problem with regard to norm setting: as research has not yet produced regression functions, and as no clear ideas exist among experts about the effects of working conditions on outcomes in the case of MIW, there is no good basis for setting a minimal or optimal norm. We seek the solution for this problem in the involvement of workers as evaluators. By asking their judgment about criteria and norms we may also account for possible differences among workers, and between workers and professionals in the importance assigned to different outcome variables.

4. The method

The method under development shall serve as a supportive tool for analyzing MIW with the aim of work (re)design. It must yield a description of the actual work, in terms of situational conditions, human activity and outcomes on the one hand, and provide recommendations for design on the other hand. Two types of application are aimed at. In case of existing jobs the analysis is based on workers real activity, and recommendations for redesign are produced (corrective design). In case of designing new jobs, the analysis starts from the projected

conditions, tasks and worker characteristics, and tries to yield design recommendations based on prediction of activities and outcomes (prospective design).

Domain

In principle the method should cover the whole domain of MIW, which contains jobs that differ considerably in skill level, and have a different mix of routine and creative components, and are to be found at different levels in the organization. On the one hand one finds jobs with an emphasis the processing, maintenance and control of information, i.e. on data-entry, data-processing, data-collection and data-retrieval, like many office and administrative jobs in which VDU's and computer-based tools are often used. On the other hand there are jobs with predominantly creative activities, like technical, scientific and artistic jobs.

Level of analysis

The focus of the method is on the 'within-job' level (Roe & Meijer, 1990), i.e. it deals with features of the work environment, tasks, and work behaviour confined by the job. Aspects of the organization and collective behaviour are taken into account, but the allocation of functions to organizational units, and the division of tasks across jobs are left out of consideration. Similarly, technology is only looked upon as it manifests itself at the level of the job. It is opinion of the authors that the method should be used in the context of a multi-level design process, and in combination with methods that cover the 'higher' level of the socio-technical system.

Scope

In terms of content, the method covers:

- 1) the objective conditions of the work, including the social and physical settings and objective tasks
- 2) the flow of the actual work activity and its regulation
- 3) the outcomes of work activity, both 'personal' outcomes such as fatigue and workload, satisfaction, need fulfilments, and 'organizational' outcomes such as productivity, sickness rates etc.
- 4) the required and actual capabilities of the category of workers that is supposed to perform the job.

Users

The method is to be used by expert analysts in cooperation with workers. Analysts can e.g. be work and organizational psychologists, ergonomists, personnel administrators etc. The analysts must be familiar with the theoretical basis, definitions and procedures of the method, as laid down in the manual. The participation of the workers is essential, both during the data-gathering stage, and in the final stage where (re)design proposals are to be evaluated.

Data collection methods

The methods used for data collection include:

- document-analysis; examination of written material relating to the job (job description, career ladders etc), work processes (flow of material, products, technical support etc.), and work outcomes (productivity data, sickness rates etc.);
- object analysis; examination of information objects and systems, forms, procedures, and reports used by the worker, and identification of entries or transformations made (or used) by the worker in comparison with other workers;
- questionnaires; systematic collection of self-reported data on personal work outcomes (fatigue, workload etc) and on competencies;
- self-recordings; examination of the worker's appointment calendar, diary, log book, and similar sources of information, with regard to the pattern and frequency of work activities over time (especially for un-structured work);
- observation and observation interview; study of the job in situ, focusing on the actual activity in its social and technical context, procedures, materials and information used, sequence and duration of activities, interruptive factors, etc.;
- semi-structured (individual) interviews; collection of detailed data on specific aspects of the job and work activities (worker), and general data on the formal aspects of the job, work processes, productivity and well-being (supervisor);

Criteria

Two sets of criteria are used: (a) outcome criteria, including 'personal growth' and 'endurance' as defined by Hacker (1986), and (b) activity related criteria, i.e. 'completeness of activities', 'action facilitation' and the 'absence of regulation hindrances' on the within-job level.

Stages of analysis

The overall structure of the analysis is depicted in Table 1. There are seven major stages, each of which is briefly described below. The description focuses on the corrective use of the method. In the case of prospective use there are some slight differences in procedure.

Table 1. Overall structure of the analysis

<i>Stage</i>	<i>Description</i>	<i>Participants</i>
Stage 1	Orientation on work process and job	analyst, manager(s), union-representatives, supervisor
Stage 2	Collection of data on work & context	analyst, supervisor, worker
Stage 3	Work & Job description	analyst, worker
Stage 4	Data-analysis	analyst
Stage 5	Work & job evaluation	analyst
Stage 6	Development of (re)design proposal	analyst
Stage 7	Participative consolidation	analyst, worker

Stage 1. Orientation

During this stage the method is introduced. Documents on the production process and the relevant jobs are gathered and reviewed. A preliminary interview is held with the direct supervisor of the job incumbent, focusing on the formal aspects of the job (structure, responsibilities, history, social and technical embedding etc.). Also, the main problems with respect to productivity, sickness leave rates, working conditions, etc, if any, are identified. The result is an inventory of points of analysis, an overall description of the job to be analyzed, and a number of indicators for problems with well-being.

Stage 2: Data collection

Data collection is mainly concentrated in this stage. Sometimes a flexible or iterative process of data collection is desirable, depending on situational circumstances and the complexity of the job (cf. Resch, 1989). Work behaviour is assessed in a kind of 'subjective activity analysis' (Ulich, 1981). First, a semi-structured interview is conducted with one of the workers, concentrating on the activities performed, goals to attain, procedures to follow, the material, people involved, constraints met etc., including time aspects. Thus questions pertain to the What, Why, When, With Who, With What, and If-Then of work activity. This is followed by observation of the work in situ, concentrating on the same aspects of work

mentioned in the interview. During 'naturally' occurring pauses, actual work performance and/or retrospectively, subjects are asked to verbalize their action-related cognitions and accompanying emotions. In addition, work objects are studied in order to find indications about the complexity of the work, mental demands, and levels of regulations required. In the case of non-sequential work with high autonomy levels subjects are asked to keep a time record and to show agenda's, calendars etc., in order to assess the time-structure of the activities. Finally, questionnaires dealing with personal outcomes (e.g. health complaints, tendency to leave, job satisfaction etc.) and capabilities used, are administered.

The result is a set of raw data on the goals, structure, content, and conditions of the work, abilities required and effects. This stage is supported by forms and procedures, interview schemes, observation charts etc. Different procedures adapted to specific categories of MIW (e.g. 'administrative supportive', 'counter-client directed', 'managerial' and 'supervisory', 'project-work', 'professional', and 'process operator' work), which seem to put different requirements to the analysis, are under development.

Stage 3. Job/work description

The description of the work is first done in domain specific terms, like kind of tasks, responsibilities, roles and training time (when specified) etc. called the 'formal description of the job'. Next, an 'actual description of work behaviour' is made, consisting of statements about frequency and duration of task performance, relative importance for the job, sequence of tasks, tools and information involved, cooperation and communication aspects etc. These descriptions serve two goals, i.e. (1) getting acquainted with the job and work processes, (2) derivation of performance requirements in terms of kind and level of information-processing activities (c.f. next phase). The manual provides checklists of frequent performed mental actions, guidelines for writing tasks statements, forms etc. In case of uncertainties, in a review session, the work description can be checked with the worker(s) on accuracy and completeness.

Stage 4. Data analysis

Data analysis constitutes of the integrative processing of the data, with two primary focuses, i.e.: 'profile analysis' and 'action facilitation analysis'. Both are supported by 'sub-analyses' that highlight specific issues from an integrative point of view, allowing for easier inferences for both main analysis goals.

The main analysis consists of:

Profile analysis: On the overall job level, the data are integrated and transformed into scales (c.f. TBS-GA scales). This is done on the basis of expert judgements by the analyst, supported by definitions, procedures, examples, given in the manual. It leads to a profile of work and demand characteristics of the actual situation.

Action facilitation analysis: The AF- analysis focuses on the various stages in the actions and their embedding in the work situation. Task-related conditions and constraints (e.g. information, social, time-structure, complicatedness, tools) are examined in relation to three main aspects of the work: time pressure, job-inter-dependencies, and severity of consequences of interruptions (or delay, errors) for task performance.

The 'sub-analyses' refer to:

- *task-structure;* specific focus is on the factors that contribute to the preparation of actions, e.g. transparency of tasks (anticipative results, clarity of procedures and methods), the control over actions (complicatedness), and completeness of actions.
- *task situation;* special analytical points are the degree of freedom and level of control for the execution and planning of actions, stemming from factors of the task context (technical, informational, social, organizational).
- *time-structure;* the time dimension of activity is a special focus point in the analysis of the complexity and degrees of freedom in planning and decision making phases of actions.
- *objects;* features of the objects and the character of their transformations form indicators for the complexity of related actions and problems in all phases of action regulation, varying from transparency of operations, anticipation, completeness of actions etc.
- *social context;* special attention is directed towards the degree in which cooperation and communication is required, the kind of complexity of social communication activities etc.. This sub-analysis can form a kind of object analysis, e.g. in cases of counter work.
- *performance requirements;* specific focus is on the kind of information-processing activities (orientation, perception, decision-making, knowledge operations) and level of required mental performance (problem-solving operations, abstraction in processing operations) as well as basic mental requirements (memory, perception and concentration).
- *requirements analysis:* at present, we are still developing an instrument to assess the required and available capabilities of the workers directly (questionnaire, rating-scales).

Stage 5. Job/work evaluation

The evaluation of the work consists of three parts:

1. comparison of the actual work, demand and context characteristics with a normative 'minimum profile' identifying changes that are minimally required in the view of well-being; this comparison also estimates the potential design-space (freedom for design) for every characteristic: the bigger the difference between the actual situation value and the highest possible value on the characteristic-scale, the greater the potential design-space;
2. comparison of required capabilities with available capabilities on structural deficiencies, i.e. establishment of training needs;
- 3) compilation of regulation hindrances taking into account time pressure, job-interdependencies, and severity of interruptions consequences.

Our plan is to develop criterion-validated example-profiles for minimum requirements for specific kind of jobs or groups of workers (according to some biographical characteristics or individual differences).

Stage 6. Development of (re)design recommendations

The criteria for evaluating the work are 'translated' into designable features of the job, analogue to the structure suggested by Rudolph (et al, 1987) in the TBS-GA. That is, when the job is evaluated by comparison of the actual job-profile with the minimum-profile, the deficiencies can be looked up in a table, from which design recommendations are derived. This results in general design-paths, with prognoses about the effects. The actual design in the work situation, of course, needs some adaptations, according to the specificity of the task content, work processes and technical and social constraints put upon the degrees of freedom of the design.

Stage 7. Participative consolidation

In an interactive session with the workers involved, it is first checked, whether there exists a general agreement about the description of the actual work situation. Second, it is discussed, what is thought of the proposal(s) for re-design, as developed by the analyst. These group-sessions are meant as a final judgement of acceptability of the found effects in terms of well-being, and the potential effects in the target situation. Concrete design points/elements can form a basis for discussion too, depending on the constraints and

possibilities at hand (defined by financial, technical or social limits). In the manual suggestions are made concerning the structure and processing of such meetings (e.g. nominal group techniques).

As might be noticed from this overall structure, the implementation-stage of the design proposals does not belong to the scope of the method at hand, although it might be elaborated in this direction in the future.

5. Evaluation and conclusions

The current state of development is that the overall structure of the method has been laid down, and the main part of the manual has been written, including aids such as instruments (interview schemes, observation-charts and checklists, job characteristic-scales), identification-aids (for work objects, materials, and tools, index-list MIW activities, (re)design recommendations related to specific deficiencies), interpretation-aids (definitions, decision trees, examples of high versus low complex activities, procedures for various analysis and processing stages), data-processing aids (forms and procedures), miscellaneous (coordinating correspondence, laws) etc. The data-gathering methods have been tried out in a case-study setting. Adaptation shown to be necessary, especially on the level of support given to the analyst. The collection of data was not the biggest problem, but rather to find ways to process them in an economic way. As the method is developed in cooperation with field experts, familiar with job analysis and design, such practical considerations receive quite some attention. After completing the manual we want to test the methods again in a field setting, in order to see whether the administration works well, and whether the design criteria, formulated at the beginning of the project will be met.

We are inclined to conclude that the method in its present state, meets the objectives posed, i.e.:

1. The analysis of MIW is feasible by using observation in combination with other data-collection techniques.
2. By providing detailed aids for orientation, identification, interpretation, data-collection, data-processing and analysis etc., the method has the features of a supportive

aid for the analyst. This tool may help to reduce the chances of unreliability (cf. Leitner et al 1987), although this has to be settled in future.

3. Validating norms related to well-being should take into account the possible individual and field variation; norms should therefore be 'adapted' to the actual 'situated task', i.e. be applied with the participation of the workers. This is what happens in our method.
4. AF is, in our view, an useful approach for dealing with the problem of designing for individual differences. 'Autonomy', frequently used as the ultimate solution for this issue, might, used without AF, turn out to be an aversive work characteristic for workers who are not sufficiently trained or not oriented towards the actual 'use' of this freedom.

A number of unresolved problems which we have met, will need additional research.

1. The most severe problem is our limited understanding of the higher cognitive activity of humans in interaction with work tasks and situations. We especially need theoretical frameworks modelling the multi-causal dimensions of relationships between person-environment interactions and outcomes of work in case of MIW.
2. The question about the interrelations between the two ultimate design objectives - performance efficiency and well-being - should be resolved by specifying the conditions under which the two relate positively, negatively, or not at all.
3. Possible systematic differences in recommendations for (re)design, resulting from the application of our method to specific groups of workers (e.g. educational level) and field conditions, should be elaborated.

Research of this type will help to achieve a better understanding of the new type of work that we have called MIW, and help to develop the methods that are needed for shaping this work in accordance to human capabilities and limitations.

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