

Stress and strain in mobile IT-supported work: an empirical study in the area of mobile services involving smartphones, notebooks and similar devices

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Abstract

Design and organizational issues and problematic aspects of mobile IT-supported work performed by *service technicians* were examined by a quantitative study of the associated stresses and strains. The study differentiated between stress dimensions of a technical and organizational nature on the one hand, and their consequences, i.e. strain, on the other. This differentiation in turn enabled conclusions to be drawn for specific recommendations for occupational practice. Reductions in impairing stress and impairing strain were to be achieved by selective prevention measures and improvements to the technical equipment used by the workers. Specific measures derived for implementation in occupational practice are outlined.

Introduction

The world of work is undergoing a sustained process of digitalization. The mobile use of digital systems in the form of mobile IT-supported work has numerous consequences, not all of which are immediately apparent. Beginning with the breakdown of established forms of work organization and the decreasing scope for individuals to identify with the contexts of traditional employment (cf. Bretschneider-Hagemes & Kohn, 2010), through to safety risks caused by the on-board use of mobile information and communications technology (ICT) in vehicles, numerous issues of major relevance to occupational safety and health can be identified. For some years, the Institute for Occupational Safety and Health (IFA) of the German Social Accident Insurance (DGUV) has conducted research into such work systems, which can be grouped under the heading of mobile IT-supported work. Publications and firm recommendations for various work scenarios with the focus upon safe and humane work have been produced as a result.

In order to counteract the existing dearth of quantitative data on the stress situation associated with mobile IT-supported work and to provide a basis for preventive activity, a theoretical standard paradigm of the labour sciences (stresses and strains, based upon EN ISO 10075-1, cf. also Rohmert & Rutenfranz, 1975 and Cox et al., 2000) was operationalized in a dedicated approach within the current research activity, and used as the basis for an empirical study. The groups studied comprised

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mobile service technicians, responsible for example for maintaining telecommunications networks. Working over a wide geographical area, these technicians make intensive use of the most diverse mobile ICT equipment in order to complete and document maintenance tasks. Equipment typically includes netbooks and notebooks, smartphones, computerized instruments, satnavs, etc. Rather than being used sporadically as an aid as was observed in the early days of mobile ICT, the equipment is now used systematically; its users are now dependent upon it and its trouble-free operation. The suspected sources of stress were studied with regard to their relevance by the measurement of stresses (the total objective influences upon the individual) and strains (individual impact, moderated by personal resources), and the statistical relationships between the two. For this purpose, a broad discussion was conducted in which hypotheses were gathered, supported by field observations and assigned to potential stress dimensions. The aim was to identify which stress situations should be optimized, be they of a technical or organizational nature. In the interests of concision, the description below discusses only selected key aspects.

Operationalization

Operationalization involved the distinction between stresses on the one hand and strains on the other. The terms “stress” and “strain” as such imply no value judgement; the adverse forms of stress and strain are termed “impairing stress” and “impairing strain”. In order for the problematic forms of stress and strain to be identified, the analysis was structured by the creation of generic dimensions on the stress side (see Figure 1).

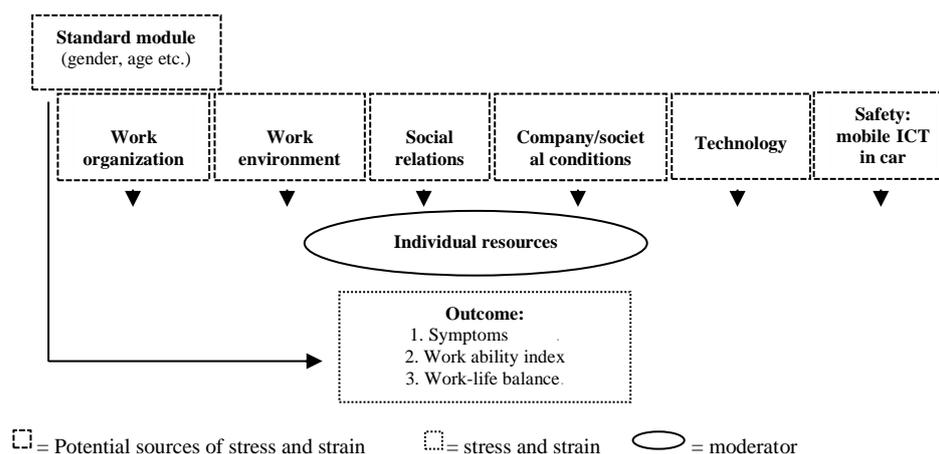


Figure 1. Research design/operationalization

The dimensions constructed in this way are specifically those of work organization, work environment, social relationships, company and social conditions, and technology. In many situations, a complex interaction was observed between the use of mobile IT and diverse objective factors influencing the work system. The research design is able only to operationalize this objectivity as adequately as possible and to study it with regard to its stress factors associated with the use of mobile IT.

All dimensions constructed in this context and populated with items were reviewed for their internal consistency and legitimized by Cronbach's α . In addition, the strain level was studied by means of three survey instruments employed in parallel (see Figure 1). These were the work ability index (2nd dimension: test subjects' own estimation of their work ability in relation to the demands of the work; cf. Hasselhorn & Freude, 2007); a proven index of symptoms (cf. Ertel et al., 1991) used to measure the state of health; and certain work-life balance items. This procedure enabled the effect of specific work conditions and work equipment to be compared.

Results

The study was based upon a random sample (N=233, returned questionnaires = 100%) of service technicians performing relatively homogeneous tasks. Mobile IT was used for the purposes of documentation, communication and navigation, besides the technical work itself. The data were obtained from a questionnaire completed by the test subjects themselves following an introductory talk at the workplace (team meeting). As expected, the composition by gender was very one-sided, with male workers accounting for 99%. The average age was 48.5 years. The individuals questioned had already been working with mobile IT for an average of ten years and with an average usage intensity of 3.6 hours per day. Up to 74.8% (with strong variations according to region and technical equipment) considered their work situation to have deteriorated on balance by the use of mobile IT. In this context however, the charge was disproved that older employees are less well disposed to the use of mobile IT. The variables did not indicate any such correlation. By contrast, poorer estimations regarding the potential for stress and impairing strain were invariably found among persons with a negative fundamental view of the use of mobile IT. For example, negative views both of the work organization and of the work-life balance correlated with the negative fundamental view (statement: The situation has improved/deteriorated as a result of mobile IT). This does not however mean that the former is the cause of the latter.

Such negative attitudes are not without justification. On the whole, initial motivation for the use of new technology disappears when technical failures begin to occur and the personal tolerance of frustration is exceeded (cf. Hoppe, 2010). In view of this, the introductory phase of new technology in particular can be considered decisive. A comprehensive pilot phase and granting the users a say in the planning phase therefore pay off in the long term. During observation of the interaction between generic items that do not correspond to any constructed dimension in the area of stresses (standard module) on the one hand and strains on the other, a notable observation was that neither the length of use (in years) nor the daily duration of use of mobile IT had a statistically significant effect upon the strain. The pointed emphasis that the longer IT-supported work equipment is used, the more stressed and more ill the users are is in the first instance shown to be a prejudice.

Health, WAI and work-life balance

Health: The health of the individuals surveyed was described by the recording of scales of symptoms. The symptoms were selected based upon a reference study

conducted among service technicians (cf. Ertel et al., 1991). Musculoskeletal complaints were those most frequently stated (see Table 1). Approximately 76% of the individuals surveyed (averaged across each group of technicians) indicated that they suffered from back complaints; 69% indicated shoulder/neck complaints. These were followed by typical symptoms of mental strain, for which the values were also high: 64% suffered from inner restlessness and tension; fatigue/weariness was a factor for 55%; 48% complained of concentration disorders; and 43% experienced increased irritability. The levels of these conditions were generally more severe than those suffered by the reference group, specifically with regard to physical/ergonomic area aspects. In addition to work conditions that may have been less favourable – the survey of the reference group was conducted at the beginning of the 1990s, without the influence of ICT – one reason may be the relatively high average age of the random sample. The trend towards musculoskeletal disorders is at any rate confirmed clearly here and points to ergonomic deficiencies in the work equipment and workplaces of the mobile workers.

Table 11. Selection of symptoms, comparison

	Reference	Random sample
Inner restlessness %	73%	64%
Back pain %	64%	76%
Concentration disorders %	64%	48%
Shoulder/neck pain %	55%	69%
Irritability %	55%	43%
Fatigue/weariness %	55%	55%
Changes in eyesight %	50%	60%
Headaches %	27%	39%
Joint pain %	14%	34%

Work-ability index (WAI): The work-ability index was recorded in its second dimension, the work ability in relation to the demands of the work. Work ability refers here to separately surveyed mental and physical criteria in relation to the demands of work, and is regarded as a reliable indicator that deviates only rarely from third-party estimations by experts (cf. Ilmarinen 2003, p. 94). Estimations of the physical work ability differed: a good 44% considered their physical work ability to be mediocre or more bad than good, 56% considered it good to very good.

Table 2. WAI values, comparison

Mean values of the WAI reference database (University of Wuppertal) and mean value of the random sample			
	Mean value	SD	N
Reference	7.44	1.501	8,330
Random sample	6.89	1.562	209

Around 56% rated their mental work ability as mediocre or more bad than good. A weighted total was calculated from the values for the mental/physical work ability according to task profiles. This total can be compared with the values from comprehensive reference data (see Table 2). If the respective mean is taken as the reference, the value attained for the estimated work ability is seen broadly on average to trend slightly negatively (random sample = 6.89, reference = 7.44 with a best possible value of 10 and a possible negative value of 2). In view of the clearly negative indications of health symptoms, the estimations regarding the WAI appear somewhat optimistic. The reactivity in response to the survey should be considered during interpretation of the data: possibly being unable to satisfy demands may give rise to negative feelings and fear of repercussions.

Work-life balance: The total value for the work-life balance was operationalized by the adjacent non-vocational areas of family, partnership and other leisure aspects. 54% of the workers stated that the mobile IT-supported work caused significant to high perceived stress in the non-vocational areas of their lives. Availability at all times as a consequence of mobile ICT was repeatedly raised as a major problem in both the questionnaire responses and interview situations. Many employees had difficulty separating working and vocational life. Some employees felt that they were being checked on by the use of mobile ICT, particularly by means of their mobile telephones. In addition, some individuals complained of being controlled by always being expected to respond immediately to telephone calls and e-mails. Criticism was also levelled in this context at the scheduling practices of some employers. The affected employees would like to have a greater say in this area. The industrial partners were advised to clarify issues of reachability and availability in company agreements. Procedures for the issuing of appointments and for planning journeys were also criticized, particularly with regard to their compatibility with family life.

Impairing stress and its relationship to impairing strain

The most important results for the dimensions created in the area of stresses (see Figure 1) are described in condensed form below, and their relationships to the defined strain values outlined.

Work organization: The dimension of work organization fared negatively in the estimation of the survey participants (see Figure 2). 77.4% considered themselves exposed to significant to high impairing stresses. The variable with the strongest negative influence upon this total value was the tightness of the schedule. 75.8% of those surveyed indicated the stress value here to be significant to very high. The individuals surveyed would appreciate a greater say in scheduling. The variable of multitasking is also conspicuous for its substantial stress values, which 71.3% of those questioned state to be in the range from significant to very high. One observation was continual interruptions to the primary maintenance tasks by calls by dispatchers and superiors.

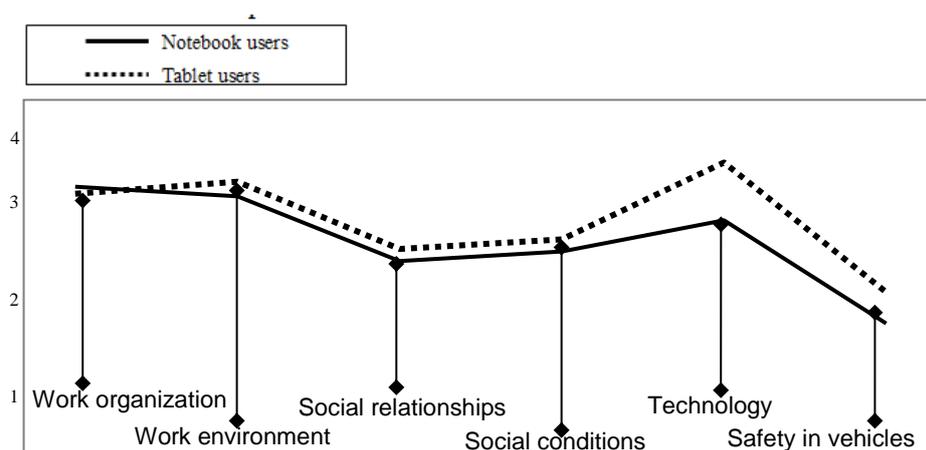


Figure 2. Region of the stresses, overview (clustered estimations of the subjects – 1 = no impairing stress; 2 = impairing stress; 3 = significant impairing stress; 4 = high impairing stress – groups differentiated according to work equipment of notebook and tablet PC)

A further complaint voiced in interviews was of typical work situations that were often performed under adverse conditions. These included working in dark and dirty and in confined spaces. Documentation work was frequently performed without desks or similar. Work with mobile IT was then carried out with no work surface whatsoever, in the vehicle or on unsuitable work surfaces.

The most significant effect ($p < .05$) is that of the total value of the work organization upon the work-life balance strain (see Figure 4). The correlation here is moderately strong ($r = .400$). The strain elements of health ($r = .273$) and WAI2 ($r = .286$) also correlate significantly. It was thus demonstrated that unfavourable circumstances in the organization of mobile IT-supported work are closely related to impairing strain upon the individual (particularly that associated with the work-life balance).

Work environment: Among those surveyed, the work environment had not changed directly as a result of mobile IT. The demands resulting from the combination of use of the equipment and the environment had changed, however. Those affected may for example be responsible for the condition in which their equipment is kept. The equipment is however regularly used under adverse weather conditions. In the cases observed, the equipment was not adequately prepared for such use, even though the market provides a more than adequate range of products for this purpose. In these and similar cases, it is notable that equipment is frequently purchased and used without consideration or adequate acknowledgement of the actual working conditions. The work environment in general was rated by 77.4% of those surveyed as being significantly to very stressful. The strongest negative influence upon this total value was the variable of stresses arising from unfavourable work locations. 75.9% of those surveyed stated a significant to very high stress value in this case. The street, construction site and the vehicle were stated as examples.

The variable of creation of a new mobile office was conspicuously negative, with a value of around 70% (significant to very high stress). Complaints were voiced

regarding the problems entailed by having to improvise a workplace under continually changing conditions. The clearest effect was that of the total value for the work environment upon the perceived work-life balance (see Table 2). A significantly ($p < 0.05$) positive relationship was observed here ($r = .351$). The strains of work-life balance and WAI2 also correlated, with weak significance. It was thus demonstrated that unfavourable circumstances in the area of the work environment of mobile IT-supported work are closely related to impairing strain upon the individual.

Social relationships: Reference studies, including studies in the area of home-based teleworking (cf. Kleemann & Voß, 1999), have repeatedly drawn attention to the issue of social isolation. The associated discussion tends at times to view work performed in isolation from the outset as negative. Interestingly, this depends however very strongly upon the attribution by the affected individuals, i.e. upon their personal resources. The preferences of individuals, i.e. whether they prefer to work alone or not, must be taken at face value. Mobile IT-supported work doubtless leads to formerly stationary forms of work now being confronted with this fact. The attribution of negative consequences solely to the use of mobile IT and the drawing of conclusions on a purely technical level would not however appear to be geared towards resources and solutions. The results of the present random survey further indicate that the enhancing of personal resources by targeted programmes for the development of skills and accompanied by structural provision for regular networking between the mobile workers could be more constructive in terms of reducing strain. Social relationships at the workplace were classified by the participants in this survey broadly on average, i.e. by 46.8% of those questioned, as being associated with significant to very high impairing stress. Up to 54% of those questioned (depending upon the sub-group) however associated the variable of isolation with significant to very high stress. The term loneliness appeared repeatedly in isolated free-text responses. Employers must also appreciate that much of the information communicated implicitly within an organization (unwritten rules) may pass mobile, isolated workers by. Informal chats are in fact frequently underestimated as a functional medium within companies. The clearest effect is that of the total value of social relationships upon the work-life balance and the workers' own estimation of their mental and physical work ability, WAI2 (see Figure 3). In this area, a weak but significant ($p < 0.05$) relationship is observed ($r = .335$ and $.405$). The related issue of scope for staff participation had already been raised by Klemens in relation to the resulting burnout risk and recognized as a considerable influencing factor (Klemens et al., 2003). It was therefore demonstrated that the quality of social relationships in mobile IT-supported work exhibits relationships with impairing strain upon the individual.

Technology: The stress dimension of technology can be interpreted as the origin of numerous forms of strain. It is important however to consider that many forms of strain attributed prematurely to technology become relevant only through the relationship in particular situations with the specific work organization and work environment. Almost the full range of assumed technical deficits were encountered. Input devices were often unsuitable, since they exhibited ergonomic deficits. Displays exhibited glare, were highly reflective, and often could not be adjusted to

the lighting conditions. Data transmission was frequently unreliable, or no network access available. In addition, software applications were often not suitable for the practical work procedures. The source of strain of technology is notable for having comparatively clear negative aspects (with values for tablet users being even worse than the average value stated). 74.9% reported significant to very high impairing stress. The variable of software ergonomics is shown to have the clearest negative influence upon the total value. The questionnaire focussed upon the criteria of usability. The adaptation of the user interfaces to the small screens of mobile devices can be regarded here in particular as unsuccessful. The variable of technical failure is conspicuous, receiving a negative rating of 70.5%. The notebooks and tablets used, i.e. the hardware side of mobile IT, were not in any way equipped for use under adverse conditions, but were merely conventional business products. Total failure was correspondingly frequent, causing interruptions in the workers' productivity, to their disadvantage (time pressure). It was also demonstrated that where the technical equipment of mobile IT-supported work exhibited deficits, the result was impairing strain upon the individual. Significant correlations were seen with all surveyed forms of strain. Specific products for improving the situation were recommended following market surveys and laboratory tests.

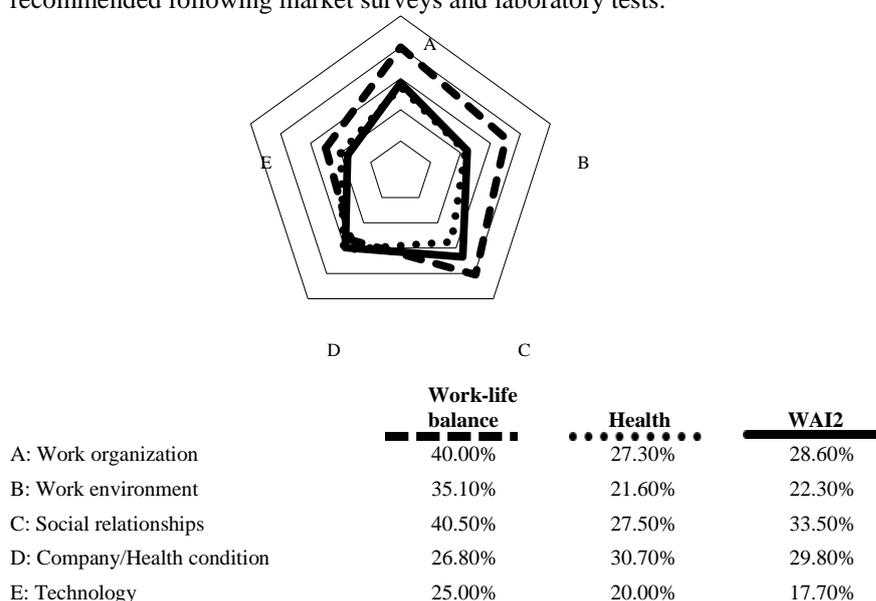


Figure 3. Relationships between stresses and strains, overview ($r = 1$ is treated as 100%)

Discussion

The present study represents a quantitative reference points in the study of mobile IT-supported work. An established standard paradigm of the labour sciences (the stress/strain model) was operationalized and applied in combination with observations in the field and interviews (method triangulation). Results were obtained for the specific fields concerned. The service technicians proved to be an occupational group yielding useful study results. The assumption of high mobility

among these employees was confirmed, as was the diverse and intensive use of mobile IT. The interpretations and observations enabled a substantial need for improvement to be identified within all the sources of strain (stresses). The key factors leading to impairing strain were shown to be not, for example, greater age or the daily duration of use, but the way in which mobile IT-supported work is organized, the form taken by the work environment of mobile workers, their social relationships, and the quality and usability of the mobile IT (hardware and software). The most important individual variables were presented and related to the field. In view of the particularly critical strain source of technology, a surprisingly high relevance must be accorded to the work equipment. Product tests in the IFA's laboratories enabled recommendations to be made for ergonomic and usable equipment. The high luminance and the reflection properties of the screens in particular led to product recommendations in the area of rugged computing.

The statistical studies enabled the assessments of those surveyed to be related to the findings from the field studies. At the same time, it became possible to identify probable consequences of impairing stress in the form of impairing strain (outcome), and to compare these with reference groups, at least to some extent. A useful body of data is thus available for the pending prevention work and can be used to launch the necessary changes purposefully and selectively.

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