NES2015

Creating Sustainable Work-environments

Lillehammer, November 1.- 4.

Nordic Ergonomics Society

Norsk Miljøpsykologisk Nettverk

NEHF
Norwegian Society of Ergonomics and Human Factors

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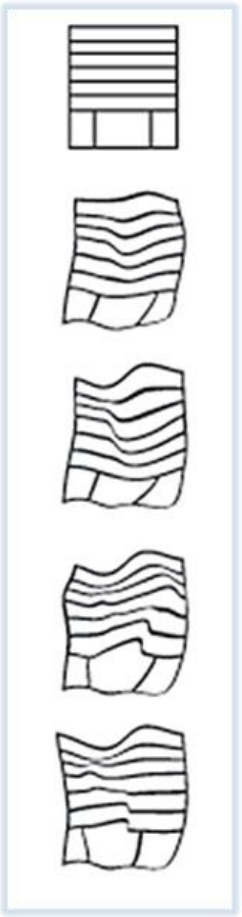
Creating Sustainable Work-environments

Proceedings of NES2015

Nordic Ergonomics Society 47th Annual Conference

01 – 04 November 2015, Lillehammer, Norway



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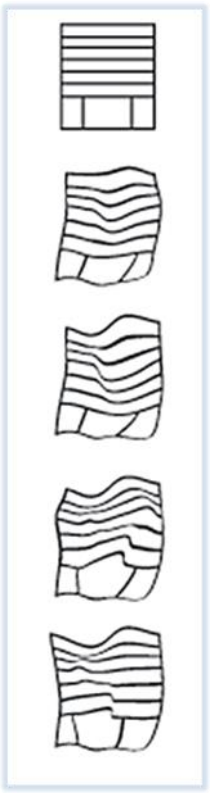

Creating Sustainable Work-environments

Nordic Ergonomics Society 47th Annual Conference

01 – 04 November 2015, Lillehammer, Norway

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Co – organizer:

NMN – Norwegian Network for Environmental Psychology

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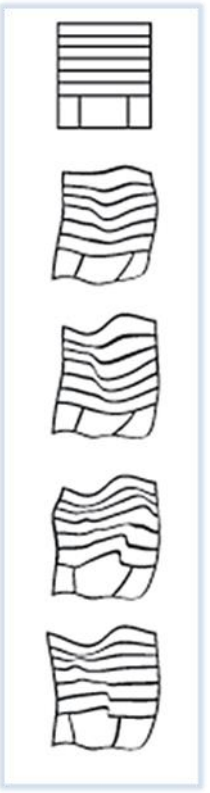

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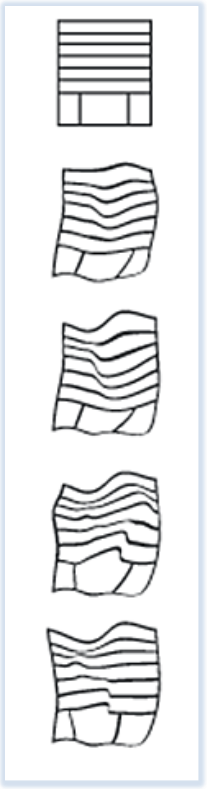


Creating Sustainable Work-environments

Dear friends and colleagues

It is our great pleasure to welcome you all to the Nordic Ergonomics and Human Factors Society annual conference in 2015 to be held in Lillehammer, Norway on the 1th-4th of November 2015.

NES2015 is a joint venture between The Norwegian Society for Ergonomics and Human factors – NEHF and The Norwegian Network for Environmental Psychology.

The topic for NES2015 focus on the challenges ergonomists and other experts encounter when aiming at developing work-environments that meets the requirements of people and societies in the new globalized economy. Too often research and practice tend to focus on narrow parts of the field, although most people easily acknowledge that the work-environment is an indivisible whole. Psychosocial-factors at work cannot be comprehensively understood if the physical work-environment is not taken into consideration, and none of the two are independent of the influence from organizational factors, legislation and societal culture. Of growing awareness is also the environmental impact of work. The ecological footprint of our daily activities must be reduced if we want to maintain our existence on this planet earth. Thus, the environmental aspect needs to be taken into account if we want to talk about sustainable work-environments.

The conference topic reflects this challenging situation in highlighting the need for using and developing good ergonomics and human factors that aims at incorporating the whole work-environment into the analysis, while at same time ensuring profitability and stimulating innovation.

NES2015 have identified five main themes that we believe represent areas where there is a considerable need for input and expertise. The conference will address these topics through key-notes held by experts of high international standard. In addition, the conference will cover a broad area of topics essential for the field of environmental psychology and ergonomics and human factors.

Together, key-notes, oral presentations, poster sessions and talks will expand and enhance our knowledge and use of ergonomics and human factors and environmental psychology and contribute to the development of true sustainable work environments.

Knut Inge Fostervold
Norwegian Society of Ergonomics and Human Factors (NEHF)

Aslak Fyhri
Norwegian Network for Environmental Psychology (NMN)

Program NES2015, the 47. annual conference of the Nordic Ergonomics Society

Time	NES2015, Sunday, November 1.
17.00	**Registration opens**
19.00	**Welcome reception. Radisson Blu Lillehammer Hotel**

Time	NES2015, Monday 02.11.2015
09.00	**Registration opens**
10.00	**Welcome Ceremony:** *Chair: Knut Inge Fostervold*
10.15	**Conference opening address:** President of NES, Christina Jonsson, Sweden
10.30	**Plenary session 1:** *Chair: Leif Rydstedt*
	Keynote 1: Professor Gary W. Evans, Cornell University, USA: An ecological perspective on work environments
11.00	**Keynote 2:** Professor Marianne Törner, University of Gothenburg: Health and good fortune! Can we speak about an organizational climate for the successful organization?
11.30	**Exhibitions and Poster session** **P1:** Lindmark, U., Wagman, P., Wåhlin, C & Rolander, B. *Evaluation of workplace health among dental care employees in a Swedish county council - a salutogenic perspective.* **P2:** Gudding, I.H. *Workplace description – a useful tool in reducing sickness absence.* **P3:** Kekkonen, P. & Väyrynen, S. *Towards optimal task distribution between the nursing staff and the support services by a resilient, reliable and easily accessible comprehensive support service system.* **P4:** Ahonen, H., Rolander, B & Lindmark, U. *Patient's perception of quality of care in Swedish dentistry.* **P5:** Björklund, A. *Better working environment with recurrent ergonomics rounds.*
12.00	**Conference lunch**

Time	NES2015, Monday 02.11.2015			
13.00	Parallel sessions and workshops with oral presentations			
	A1: Future work environments - Challenges for sick leave *Chair: Reidulf G. Watten* **Osvalder, A.L., Andersson, J., Bligård, L.-O., Colmsjö, A.** *Ergonomic features of control room environments for improved operator comfort and support* **Schlacht, I., Ceppi, G., Nazir, S.** *Sustainable quality: from the Space station to everyday contexts on Earth* **Rolfö, L., Eklund, J.** *Examining Office Type Preference* **Raanaas, R.K., Bjørnstad, S. Patil, G.** *Nature contact at office work places and organizational support: benefits on stress reduction, subjective health complaints, and sick leave*	**B1: Visual ergonomics** *Chair: Hanne-Mari Schiøtz Thorud* **Hemphälä, H., Zetterberg, C., Lindberg, P., Heiden, M., Nylen, P.** *A method for assessing risks in visual ergonomics* **Helland, M., Long, J.** *Spending too much time looking at digital screens? How to avoid visual problems!* **Lindegård, A., Norlander, C., Jakobsson, H., Arvidsson, I.** *Prismatic glasses reduces neck pain in dental personnel* **Glimne, S., Seimyr, G.Ø., Brautaset, R.** *Effect of three-dimensional central visual stimuli on vergence control*	**C1: Organization, work and social environment 1** *Chair: Elina Parviainen* **Ekstrand, M.** *Social Interaction in Activity Based Workplace Concepts* **Nilsen, V., Koren, P.C.** *Destructive leadership behavior – prevalence and consequences* **Jensen, M.G.** *Mobbing and Conflict - On Irrational Critique an the Ethics of Intervening*	**D1: Musculoskeletal problems** *Chair: Jakob Ugelvig Christiansen* **Yung, M., Wells, T.** *Responsiveness and Reliability of Selected Neuromuscular Fatigue Measures for Workplace Use* **Forsman, M., Rhén, I.-M., Eliasson, K., Lindberg, P., Palm, P., Nyman, T., Balliu, N., Kjellberg, K.** *Reliability in ergonomic risk assessments by observation* **Ericsson, P., Wahlstrøm, J., Forsman, M.** *Reliability of 25 ergonomists' ratings of risks with QEC and RULA*
14.30	Coffee break, Exhibitions and Poster session			

Time	NES2015, Monday 02.11.2015			
15.00	**Parallel sessions and workshops with oral presentations**			
	A2: Workshop: Preventing sick leave: future research strategies *Chair: Reidulf G. Watten*	**B2: Legal aspects and labour inspection in future work environments** *Chair: Christina Jonsson* **Kwak, L., Wåhlin, C., Stigmar, K., Hermansson, U., Jensen, I.** *Development of occupational health practice guidelines: a Swedish model* **Johansson, M.** *New legislation in Sweden regarding the organizational and social work environment* **Petersen, G.** *User involvement – a way to successful implementation of new methods*	**C2: Organization, work and social environment 2** *Chair: Viggo Nilsen* **Power, F.P.** *Ergonomics Risk Management in the Irish Workplace: An Evolving Process* **Nazir, S., Manca, D., Øvergård, K.I.** *The Impact of Trainer on Training Transferability* **Eliasson, K., Lind, C., Nyman, T.** *Facilitators for the implementation of ergonomic interventions* **Rolander, B., Wåhlin, C., Johnston, V., Wagman P., Lindmark. U** *Organizational aspects of work load and health among occupational groups in a Swedish public sector dentistry*	**D2: NES student prize competition** *Chair: Cecilia Österman*
16.30	**Coffee break, Exhibitions and Poster session**			

Time	NES2015, Monday 02.11.2015			
17.00	**Parallel sessions and workshops with oral presentations**			
	A3 Prevention, risk assessment, safety, design *Chair: Svein Åge Kjøs Johnsen* **Aalmo, G.O.** *Enhancing safety and productivity in fully mechanized forest operations; workload influence on operator performance* **Øvergård, K.I., Paulsen, M., Nazir, S.** *Differences in the perception of normative and descriptive accident narratives* **Bligård, L.O., Berlin, C., Österman, C.** *Comparing the 2D and 3D models as tools for evaluation of workplace*	**B3: Cognitive load, gender and organisational aspects** *Chair: Andrew Thatcher* **Carlsson, R., Wersäll, M. Liljefrost, E.** *The Organization Makes the Difference* **Johansson, M.** *An approach in the field of cognitive work environment* **Wiberg, V.** *Review of the knowledge concerning the digital working environment and cognitive loads*	**C3: New opportunities in ergonomics and human factors** *Chair: Erlend Weinholdt* **Osvalder, A.-L., Colmsjø, A.** *Design features of an office chair promoting health and performance upon sedentary work* **Tobiasson, H., Gulliksen, J.** *Movement in Mind – exploring bodily approaches in Office work.* **Hägg, G.M., Södersten, M.** *Voice ergonomics – an area for collaboration between speech language pathologists, ergonomic practitioners, and acousticians*	**D3:**
18.00	End day one			

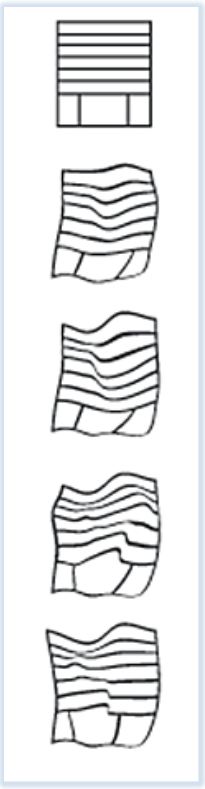
Time	NES2015, Tuesday 03.11.2015
09.00	**Welcome and information day 2:** *Chair: Knut Inge Fostervold*
09.15	**Plenary session 2:** *Chair: Svein-Åge Kjøs Johnsen*
	Key note 3: Professor Jan Dul, Erasmus University, the Netherlands: *Work environments for creativity and innovation*
09.45	**Conference address:** Knut Inge Fostervold, University of Oslo, Norway: *Sustainable work environments: What and Why?*
10.05	**Coffee break, Exhibitions and Poster session**

Time	NES2015, Tuesday 03.11.2015			
10.30	**Parallel sessions and workshops with oral presentations**			
	A4: Environment and sustainability in the workplace *Chair: Leif Rydstedt* **Calogiuri, G., Evensen, K., Weydal, A., Andersson, K., Patil, G., Ihlebæk, C., Raanaas, R.K.** *Green exercise as a workplace intervention to reduce job stress. Results from a pilot study* **Thatcher, A., Chunilal, H.** *Development and validation of a workspace layout survey for use in green building certifications* **Johnsen, S.Å.K.** *Developing an environmental organisational climate concept, a few lessons from research on safety climate* **Ahlgren, F., Österman, C.** *A social sustainability perspective on an environmental intervention to reduce ship emissions*	**B4: Visual and musculoskeletal factors in digital work** *Chair: Knut Inge Fostervold* **Johansen, T., Helland, M., Schiøtz-Thorud, H-M.** *Children's use of handheld digital devices – how to prevent eyestrain and musculoskeletal complaints?* **Mork, R., Fostervold, K.I., Schiøtz-Thorud, H-M.** *Visual and Psychological Stress during Computer Work* **Nguyen, P., Volden, F.** *One-handed use of large smartphone screens. -An EMG study of ergonomically challenging interfaces* **Oblakoff, K., Forsman, M.** *Activity in four muscles during email work with computer, smartphone and smartphone with ergonomic recommendations*	**C4: Prevention, risk assessment, safety, design** *Chair: Mads Olsen* **Jakobsson, M., Wiberg, V.** *How can future patient safety and work environment at expedition with advanced medical equipment be noted as important factors during the design and procurement phase in the perspective of an earlier serious accident?* **Lange-Morales, K.** *The Use of Medical Devices in Healthcare Institutions: Understanding Compatibility in Operating Room (OR) Technology* **Heikkilä, J., Viitanen, K., Levasluoto, J., Tuovinen, J.** *Challenges in complex adaptive healthcare systems*	**D4: Musculoskeletal disorders** *Chair: Erlend Weinholdt* **Yazdani, A., Wells, R.** *Key informants' perspectives on possible barriers and challenges for successful prevention of Musculoskeletal Disorders (MSD) in organizations* **Yazdani, A., Wells, R.** *How organizations address Musculoskeletal Disorders (MSD) prevention within their management system framework?* **Veierstedt, K.B., Hanvold, T., Lunde, L.-K., Koch, M., Wærsted, M.** *Hypotheses on causation and latency of neck and shoulder pain in low-level effort jobs* **Hägg, G., Schmidt, L.,** *Specific risks for musculoskeletal disorders at professional window cleaning*
12.00	**Conference lunch**			

Time	NES2015, Tuesday 03.11.2015			
13.00	**Parallel sessions and workshops with oral presentations**			
	A5: Workshop: The Future of The Norwegian society for ergonomics and human factors (NEHF) *Chair: Knut Inge Fostervold* *The goal of NEHF is to become a driving force in the field of ergonomics and human factors in Norway. The opportunities are plentiful, but depend on a strong and active society.* *How shall NEHF achieve this goal?* *How can NEHF attract new members?* *How can NEHF contribute to increased activity among its members?* *These and many other questions are open for discussion in the workshop.*	**B5: Visual ergonomics in practice: Workshop.** *Chair:*	**C5: Simulation, systems engineering and performance** *Chair: Kasper Edwards* **Caliscan, D., Khalid, O., Ore, F., Hanson, L.** *Simulation and evaluation of industrial applications of Human-Industrial Robot Collaboration cases* **Øvergaard, K.I.** *Human Error: Causality and the Confusion of Normative and Descriptive Accounts of Performance* **Nilsson, R., Bligård, L.O.** *PU2B-model, connecting Human Factors and Systems Engineering for effective Product Development* **Nazir, S., Manca, D., Komulainen, T.M., Øvergård, K.I.** *Training Simulator for Extreme Environments*	**D5: Transportation** *Chair: Lilja Birgisdóttir* **Van Leeuwen, W., Jepsen, J.R., Barnett, M., Åkerstedt, T., Kecklund, G.** *Long term sleep, fatigue and working conditions at sea: a field study among seafarers* **Linder, M., Tegbrandt, K.** *Implementation of RAMP method at Scania* **Zhao, Z., Jepsen, J., Chen, Z.** *Work fatigue and occupational health of seafarers – case studies in European and Chinese shipping industry*
14.30	**Coffee break, Exhibitions and Poster session**			

Time	NES2015, Tuesday 03.11.2015			
15.00	**Parallel sessions and workshops with oral presentations**			
	A6: Workshop on Ergonomics - a new anticipation and scope for 'ergonomics' *Chair: Jakob Ugelvig Christiansen* *The workshop will elaborate on the following question:* *If ergonomics is the science of work does ergonomics then embrace the broad definition of OHS?* *- Physical ergonomics (human physiology, environmental ergonomics, visual ergonomics etc.)* *- Cognitive ergonomics (mental processes)* *- Organizational ergonomics (socio-technical systems)*	**B6: Visual Ergonomics Network annual assembly.** *Chair: Hanne Mari Schiøtz Thorud*	**C6: Work environment management and changes** *Chair: Frode Volden* **Rydstedt, L., Devereux, J.** *A longitudinal study of the impact of age and job demands on wellbeing for younger and older white-collar workers* **Blomé, M., Hansson, C., Odenrick, P., Rydenfält, C.** *Stimulating innovation through small business and university collaboration* **Watten, R.G., Fostervold, K.I., Rydstedt, L.W.** *Stress hormones in the hair: A new method for investigation of stress and work-load*	**D6: Assessment methods and new equipment** *Chair: Mads Olsen* **Lind, C., Forsman, M.** *Accuracy of a posture measurement system for practitioners* **Falck, A.-C.., Andersson, L., Mattsson, S., Karlsson, M., Rosenqvist, M., Søderberg, R.** *Comparison of two methods for assessment of assembly complexity* **Yang, L., Forsman, M.** *Development and validation of a novel iOS application for measuring arm inclination*
16.30	**Exhibition and poster session**			
17.00	**NES General Assembly Annual Meeting**			
20.00	**Conference dinner, Radisson Blu Lillehammer Hotel**			

Time	NES2015, Wednesday 04.11.2015
09.15	**Welcome and information day 3:** *Chair: Knut Inge Fostervold*
09.30	**Plenary session 3:** *Chair: Reidulf G. Watten*
	Key note 4: Professor Annik Magerholm Fet, NTNU, Norway. Environmental management
10.00	**Key note 5: Information architect Jonas Söderström, Sweden: "Stupid bloody system!" Why usability fails**
10.30	**Coffee break, Exhibitions and Poster session Exhibition and poster session**
11.00	**Plenary session 4:** *Chair: Knut Inge Fostervold*
	NES Award presentation
11.30	**Presentation of NES 2016**
11.45	**Concluding remarks and closing ceremony**
12.15	**Lunch - optional (not included)**



Key note speakers at NES2015

Monday 02.11.2015

Professor Gary W. Evans: Cornell University, USA

Cumulative Risk Exposure and the Work Environment

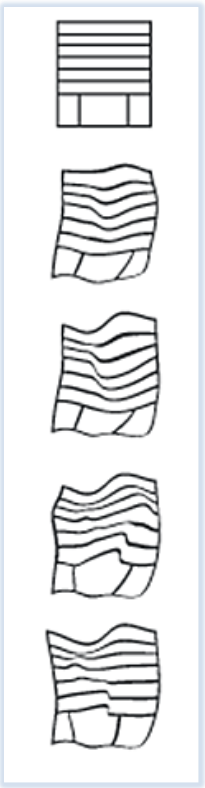
Professor Evans is an environmental and developmental psychologist interested in how the physical environment affects human health and well-being among children. His specific areas of expertise include the environment of childhood poverty, children's environments, cumulative risk and child development, environmental stressors, and the development of children's environmental attitudes and behaviors.

Professor Evans received an Honorary Doctorate from Stockholm University in Sweden in 2006 and is a former member of the MacArthur Foundation Network on Socioeconomic Status and Health and of the Board of Children, Youth, and Families for the National Academy of Sciences. He is a Guggenheim Fellow, and a recipient of the EDRA Career Award. Evans has received a Senior National Research Service Award from the National Institute of Child Health and Human Development. He has a Ph.D. in environmental psychology with post-doctoral training in psychoneuroendocrinology and in human development. Professor Evans has given several hundred lectures and invited talks in over 35 different countries.

Professor Marianne Törner: University of Gothenburg:

Health and good fortune! Can we speak about an organizational climate for the successful organization?

Marianne Törner is a visiting Professor of Human Factors at University West, specialising in safety. Her position here is 30 percent of a full-time post. Marianne Törner has a permanent position as a researcher at the University of Gothenburg, Occupational and Environmental Medicine. Here she leads the research group Safety, Organisation and Leadership, which looks at the safety climate in workplaces. Marianne Törner gained a PhD in Ergonomics in 1991. For many years she was Head of the National Institute for Working Life in Gothenburg. She is Vice Chairperson of the University Governing Board of University West.



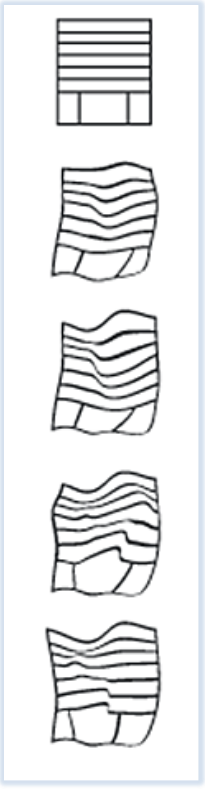
Tuesday 03.11.2015

Professor Jan Dul: Rotterdam School of Management, Erasmus University (RSM), the Netherlands.

Work environments for creativity and innovation

His research focuses on human factors (ergonomics) and, in particular, the interaction between people and the technological and social-organisational work environment. The goal of his research is to develop products, tools, production systems and procedures that can improve productivity, quality, creativity, and health and safety in the work environment, thus maximising business performance as well as human well-being.Professor Dul is currently an associate editor, reviewer, and member of the editorial boards of a number of major academic journals. He is a member of the advisory boards of various associations, agencies and institutes. He was member of the board of the International Ergonomics Association.

He is a regular speaker at management events worldwide and has shared his insights with over 50 companies including professionals in the field of innovation management, human resource management, and occupational health and safety on the specific issue of how to create work environments that facilitate employee performance and well-being. Before joining RSM, Professor Dul held a number of senior positions in the (semi) public sector. He was head of the Department of Innovation at the Netherlands Institute for Work and Employment; head of the Department of Posture and Movement Research at the TNO Institute of Preventive Health Care, Leiden; an Ergonomics Researcher at the Department of Working Conditions, the TNO Institute of Preventive Health Care, Leiden.



Wednesday 04.11.2015.

Professor Annik Magerholm Fet: Department of Industrial Economics and Technology Management (IØT), Norwegian University of Technology and Science (NTNU).

Environmental management

Professor Annik Magerholm Fet is leading several international research projects on global production, sustainable system innovation, environmental management and CSR and she is member of several international committees on environmental technical standards.

She is the director and academic head of NTNU's strategic research area Sustainability (2014-2023). She is a professor of environmental management, systems engineering and life-cycle analysis at the Department of industrial economics and technology management (IØT), NTNU in Trondheim. She is head of several national and international research projects in global production, and environmental and corporate social responsibility (CSR). She has been involved in developing the Norwegian system for environmental product declarations, carbon footprint and water footprint of products, and has worked with environmental assessment in relation to environmental responsibility in the maritime cluster.

She sits on the board of Polaris Media Northwest and for user-driven innovation program (BIA) in the Research Council of Norway (RCN). She is also deputy board member for Standards Norway, and Norwegian delegate in international committees for the development of environmental management standards. She heads a research group for environmental management and CSR at NTNU, and looks at opportunities for sustainability management and system innovation to bring about changes in various sectors

Information architect Jonas Söderström:

"Stupid bloody system!" Why usability fails

Jonas Söderström has worked with usability in computer systems and the Internet as a consultant since the mid-1990s, with assignments for a large number of corporations, organizations and government agencies. He has written several books and papers on the art and science of organising websites". In his last book entitled ("Jävla skitsystem!" in Swedish), which approximately would be "Stupid bloody system!" in English, he discusses bad IT-systems and the problems they can lead to when people forced to use them.

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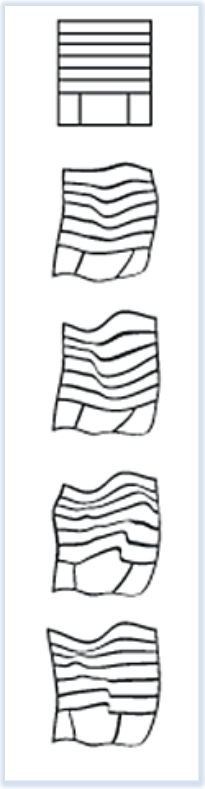

Creating Sustainable Work-environments

Nordic Ergonomics Society 47th Annual Conference

01 – 04 November 2015, Lillehammer, Norway

Oral Sessions

Ergonomic features of control room environments for improved operator comfort and support

Osvalder, Anna-Lisa, Andersson, Jonas, Bligård, Lars-Ola, Colmsjö, Anders
Division Design & Human Factors, Chalmers University of Technology
SWEDEN
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Process control operators need well-designed control room environments to focus better on tasks to be performed. The aim of this study was to evaluate if a high-end control room concept including the latest ergonomic features had any effects on operator comfort and alertness compared to a traditional control room. Twelve professional operators participated by running a paint factory simulation for three hours in each control room. Subjective estimations were given regarding perceived discomfort, stress-energy and emotional state. The results showed significant benefits of a supportive ergonomic control room environment on operator alertness, wellbeing and productivity, but they felt increased pressure to perform well in such a high-technology environment.

Keywords: Process control room, ergonomics, comfort, stress, emotion

1. Introduction

In order to control different industrial production processes in an optimal manner, operators need well-designed control room environments, to consider human machine interaction (Bligard, et al., 2008). A good design has to be based upon knowledge of ergonomics/human factors, meaning that the design should support the operators' needs, abilities and limitations from physical, cognitive and organisational perspectives, in order to optimize human well-being and overall system performance. By providing a good working environment, operators' comfort and performance will most likely increase (ISO 11064).

Recent research (e.g. Vischer, 2007) has focused on the physical environment and its effects on work performance. Research has also shown links between employee health and properties of the physical environment, such as indoor air quality, lighting and ergonomic furniture (e.g. Milton et al., 2000).

Research in ergonomics has shown the importance of variables like lighting, noise and noise control, furniture and spatial layout in offices. McCoy and Evans (2005) have suggested that stress can be triggered when properties of the physical environment interfere with plans and behaviour. A supportive physical environment should make it possible for operators to focus on the task to be performed without being preoccupied with environmental properties that interfere with the plans to be executed. Environmental comfort may, according to Vischer (1995), be a function of three hierarchically related categories: physical, functional and psychological. Physical comfort is defined as basic human needs, such as safety, hygiene and accessibility. Functional comfort is defined as ergonomic support for work tasks and psychological comfort deals with feelings of belonging and control over the workspace.

The purpose of this study was to examine how differences in the physical ergonomic design of the working environment in a process control room effects operator work experience. The aim was to evaluate if a high-end control room concept including the latest ergonomic features had any effects on operator comfort and alertness in terms of perceived discomfort, stress-energy and emotions during normal operation, compared to a traditional control room.

2. Methods

A total of twelve test subjects, eleven males and one female, participated in the study. They were all Swedish-speaking professional operators working at various process industries in western Sweden (pulp & paper, food processing, water cleaning, heat and power, chemical processing and oil refining). Their ages ranged from 26 to 53 years and work experience of process control from 2 to 35 years. Two control room environments were used in the study: a high-end conceptual control room with an optimised physical working environment including the latest ergonomic features such as large, and a traditional control room as often found in industry (Table 1). To achieve an operator-working situation that was similar to a real world industrial control room, a paint factory simulator was used. The choice of process was made with the intent to make it easy to interpret what was happening in the process, yet with the possibility to add complexity by changing the number of objects and recipes running at the same time. When mixing a paint batch, a number of parameters need to be set, e.g. water content, various colour pigments, thickening agents, binding agents and other additives.

Table 1 *Features of the two control room environments included in the study*

Features	High-end Control Room	Traditional Control Room
Area meter square	114	35
Operator workplace	ABB/CGM EOW-x3	Traditional desk
Adjustable work tables	Yes	No
Micro-ventilation in table	Yes	No
Curved table	Yes	No
Leather edges on table	Yes	No
Screens for interactive work	6 height-, tilt-, distance-adjustable screens	6 screens
Screens for monitoring	3 large height-adjustable screens in front of operator	3 large screens on the wall
Multi-client keyboard	Yes, with shortcuts	No
Office chair	Ergonomic adjustable	Standard adjustable
Reading light condition	Dimmable, 275-1000 lux	180-210 lux
Noise level	50-55 dB (A)	50-55 dB (A)
Temperature	20-25°C	20-25°C
Sound absorbents	Yes, on ceiling and walls	Yes, on screen wall
Windows	12 with adjustable blinds	3 large
Constant status light in ceiling	Normal green diode light. Emergency; red diode light.	No

Each test subject's working day started at 9 pm with a one-hour introduction of the control system of the paint factory. First, the test leader made an oral and visual presentation of the system, followed by giving the operator the opportunity to test the system and ask questions about the functionality. A few weeks before the test session, all operators had received written documentation about the simulator. Then each operator ran a three-hour shift in each of the two control rooms: one morning shift from 10 am to 1 pm and one afternoon shift from 2 pm to 5 pm. The conditions were randomly assigned to start working in either the high-end or the standard control room. A one-hour lunch break was taken between shifts. Every 30 minutes, the test leader gave the operator a paper-based questionnaire regarding their perceived comfort, stress and

emotional state. To minimize intrusiveness, the test leader always asked the operator if it was okay to pause, allowing the operator to finish the current task or thought. The questionnaire took two to three minutes to complete. During this time the simulation was paused. After the second test session at the end of the day, an interview was also conducted with the operator.

To assess operator user experience in the two control rooms, comfort and alertness aspects were evaluated. These aspects were judged by subjective self-assessment ratings of *discomfort*, perceived *stress-energy* and *emotional state* during the test sessions. Interviews were also performed to get qualitative individual data regarding the operators' experiences of the two control room environments. The subjective assessments of experience were gathered via a three-page questionnaire (in Swedish) administered to the participants every 30 minutes during each three-hour shift, resulting in six questionnaires per shift (after 0, 30, 60, 90, 120 and 150 minutes). The questionnaire included one page for each of the three rating scales chosen; discomfort ratings (Osvalder et al, 2005), the Stress-Energy Questionnaire (Kjellberg and Wadman, 2007) and the Self-Assessment Manikin (SAM) (Bradley & Lang, 1994).

The experimental study was conducted as a mixed factorial, within-subjects design, where all test subjects were exposed to the same factors; in this case the two control room concepts during morning or afternoon sessions. The non-parametric Mann-Whitney U test were used to analyse the hypotheses that the two control room environments would have significantly different effects on the operators' perceived discomfort, stress-energy and emotional states, respectively. To analyse the comfort ratings a one-way ANOVA was performed to study effects between the six discomfort parameters. For the 12 stress-energy items, statistical analyses were made for each subgroup, represented by *positive stress*, *negative stress, positive energy* and *negative energy* respectively. The emotional parameters *valence, activation* and *control* were analysed separately.

3. Results

The analysis showed that the total discomfort perceived by the operators was significantly lower ($p<0.05$) in the high-end control room than in the traditional control room regardless of time of day. However, in general, the discomfort ratings were low for all operators in both control rooms, and most operators rated discomfort in the high-end control room as nearly no discomfort at all. Furthermore, there was significantly ($p<0.05$) lower discomfort in the high-end control room for *stiffness, inconvenience, fatigue* and *pain*. For *numbness, pain* and *woody taste* no significant differences were seen between the two control rooms.

No significant differences were found in perceived discomfort between the morning and afternoon sessions in either of the control rooms. The perceived total discomfort increased over time in both control rooms during the test sessions. This result implies that the discomfort increased more the longer the working time in the traditional control room relative to the high-end control room. In the high-end control room the change over time was not as pronounced. Regarding energy ratings, the result showed that the positive energy was significantly higher ($p<0.05$) during the morning session than during the afternoon session. For the negative energy no significant differences were shown between the sessions. Regarding stress ratings, the operators were slightly more negatively stressed (*tensed, stressed* and *pressured*) during the morning session than in the afternoon. In the afternoon they were slightly more positively stressed (*rested, relaxed* and *calm*). A separate analysis of the parameter *stress* showed a significant difference ($p<0.01$) between the morning and afternoon sessions; the stress level was higher in the morning when the operators were exposed to the paint factory simulator for the first time. Neither of the stress or energy parameters showed a significant difference over time during a three-hour working session. The ratings were rather similar at all occasions during the sessions.

The emotion analysis showed no significant differences between the two control room concepts for any of the parameters valence, activation or control. Nearly all operators rated their valence as neutral on the scale from sad to happy in both environments, with a slight tendency

toward happy. Regarding activation, the operators were calm and not excited during the working sessions. Regarding control, the operators felt they had control of the working situation during the whole session, and the ratings, especially at the end of each session, were high for control. Regarding time of the day, the emotional parameter control showed a significant difference ($p<0.01$) between morning and afternoon sessions. The control was higher in the afternoon when the operators ran their second session on the simulator, as they had become more proficient.

4. Concluding remarks

The purpose of this study was to examine how differences in the physical ergonomic design of the working environment effects operator work experience in the control room. The overall result showed that the perceived discomfort is lower in the high-end control room at all times of a working day. The operators preferred to work in the high-end control room and they also felt they might perform better in this environment, but they also sensed increased pressure to perform well. This result is of course in line with what could be expected when letting people compare a new and more sophisticated ergonomically designed environment with their daily working conditions, and therefore a discussion about bias in the study is relevant. However, the ergonomic features resulted in less *inconvenience*, *fatigue* and *pain* as well as it supported the work and increased the alertness in terms of activation and energy. All these parameters were actually possible to evaluate with the selected methods, which shows that they are appropriate tools for studying operator feelings and needs. The perceived discomfort did not increase much during a working session in the high-end control room compared to the traditional control room, which indicate that the working task is as important as the environmental features. Finally the high-end control room was experienced more attractive due to its possibilities to change working postures and thereby decrease discomfort, fatigue and pain.

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SUSTAINABLE QUALITY: FROM SPACE STATIONS TO EVERYDAY CONTEXTS ON EARTH

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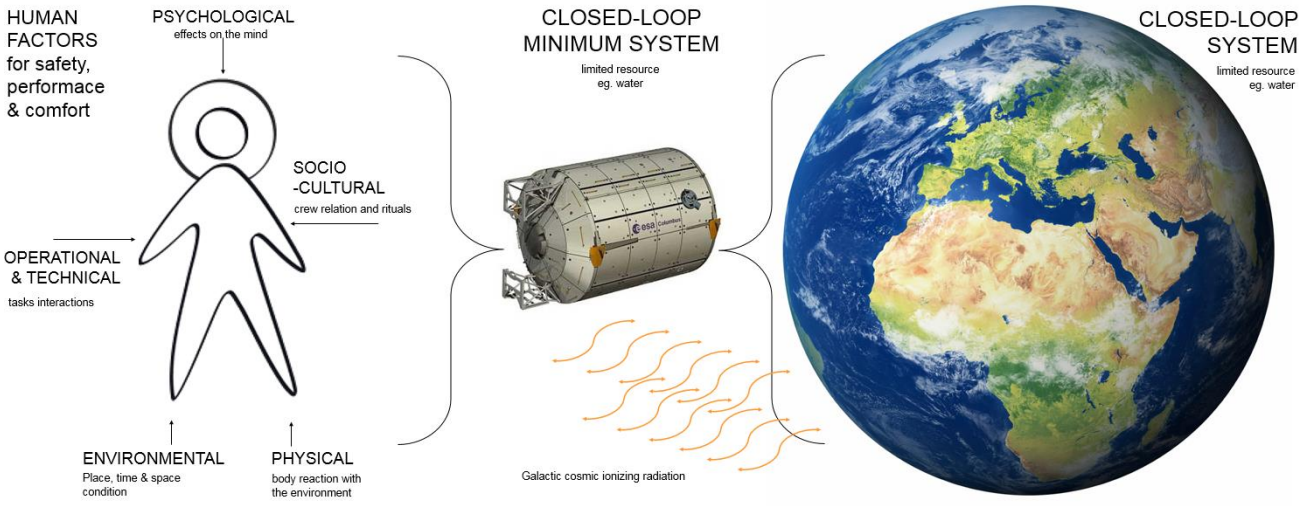
Keywords: Sustainability, Extreme Working Environments, Space Station, Human Factors Design, Closed loop, Holistic Design Methodology, Slow Approach.

Abstract

Space stations are working places operating in extreme and isolated environments. In isolation, having no access to resources, these places need to be self-sufficient and sustainable and be able to reuse their resources. The transfer from extreme to domestic environments of the sustainable logic and technologies applied in these contexts has enormous potential for the quality of our everyday lives. This "sustainable quality" can be applied, for example, to address overpopulation and the increasing need for resources and can also be used for applications in megacities (Schlacht et al., 2015, 2014). In order to achieve "sustainability quality", two main elements will be explained in this paper: a holistic methodology and a slow approach.

To transfer the system logic from Space to Earth, we need to apply a holistic methodology. This can help us to understand each element of the system and their interrelations in the present as well as in the future considering the entire life-cycle. However, to implement quality of life, we also need to apply a slow approach. This slow approach outlines a new production and consumption model that is at the same time both subversive and feasible and focuses on the quality of the experience.

Schema:. Relations between human system & Closed loop artificial & Natural Systems. (Composition © Schlacht 2015; Image Columbus ©ESA Earth © NASA)



In summary, the concept presented here is "sustainable quality". The aim is to establish the basis for implementing quality of life on Earth by transferring sustainable technologies and know-how from Space to Earth using a holistic design methodology and a slow approach (Schlacht et al., 2009).

1. Sustainability vs. extreme environments

The Oxford Dictionary defines "sustainable" as "able to be upheld". Sustainable is something that is self-sufficient, autonomous, and able to regenerate itself in a sort of perfect equilibrium. This concept is applied in different contexts, for example in the closed-loop system of an aquarium. The Earth itself can also be considered a sustainable system, as can a Space station, which is isolated in an extreme environment and needs to regenerate its own resources.

Space stations are situated in an environment to "which humans are not naturally suited, and which demands complex processes of physiological and psychological adaptation" (Kanas and Manzey, 2008, p. 15). Of the various extreme environments that human beings have been able to reach, Space is the most extreme. For these reasons, a complex, self-sustainable system is needed to support human life in it. Extreme environments include: submarine vessels, underground, high mountains, underwater laboratories, dwelling stations in desert and Antarctic areas, radioactive areas, offshore drilling rigs and, of course, Space environments. All these environments are supported by closed-loop and sustainable technologies such as the recycling of water. Isolated working places in extreme environments need to apply high-tech in order to be self-sufficient and sustainable because they do not have access to local resources. These places are thus self-sufficient systems, based on the closed or semi-closed use of resources, with very limited impact on the external environment. Extreme environments are characterized by adverse environmental conditions that are particularly unfriendly to humans, such as extreme temperatures and pressure, lack of oxygen, and the presence of radiation. In Space, we have all these environmental conditions plus other factors, such as a wholly different level of gravitational force, meteorites, vacuum, as well as other effects, such as the very sharp contrasts between light and dark or severe temperature changes. For these reasons, it is Space where we can find the application of the best technologies and know-how regarding sustainability and closed-loop systems.

2. Closed loop: aquarium = Space station

A Space habitat is meant to be a sustainable system to the greatest extent possible, a closed-loop system with autonomy from Earth. To support human life in such a habitat, each specific element of this complicated system is designed and built artificially by considering the relationships among humans and environments.

To easily understand the concept of artificial closed systems, we can imagine an aquarium where each single element has a direct influence on the equilibrium of the overall system. In the aquarium, the equilibrium between fish, plants, and water is fundamental. Too many fish will eat all the plants, resulting in insufficient oxygen, resulting in water contamination, which will eventually result in extinction of the fish in that aquarium. Just as in an aquarium, in a Space ship, on Earth, or in a closed system, the relationship of a part to the whole is extremely intensified. In this sense, the user's well-being is strictly related to the equilibrium existing within the system (Schlacht, 2012). Fostering optimal relations among all the elements that constitute the living system becomes crucial for maintaining a perspective that is as global as possible when considering each phase of the system's lifecycle (Quantius et al., 2014)

A concrete example is the NASA project EcoSphere, whose goal was to develop technologies for obtaining the perfect closed loop for a Space station. The EcoSphere is a micro-aquarium with a completely enclosed ecosystem. Its biological cycle represents a simple version of Earth's own ecosystem. While beautiful to look at, it shows the delicate balance of an ecosystem just like our own. It contains shrimp, algae, and bacteria. The EcoSphere works by

gathering energy from the light and converting it biochemically. Light, together with the carbon dioxide in the water, enables the algae to produce oxygen by photosynthesis. The shrimp breathe the oxygen in the water and graze on the algae and the bacteria. The waste from the shrimp is broken down by the bacteria into nutrients, which in turn feed the algae. The shrimp and the bacteria also give off carbon dioxide and the cycle is renewed when the algae use this once again to produce oxygen. (AAVV, 2007; NASA, 2015)

Image 1: Living in a Self-Sustaining Ecosphere (free © Wicker Paradise in flickr.com).

3. What: holistic sustainability vs. the quality of the life-cycle

On a Space station and on Earth, water is a limited resource to preserve. On Space stations, the logic of the closed loop tries to mimic the Earth's water system, recycling water from urine, waste, and sweat. The technology, the know-how, and the procedures used to create and maintain the artificial closed loop on a Space station could conceivably be applied in any environment with similar needs. In the closed loop logic, we need to preserve the entire system, holistically approaching all the elements and their interactions, such as the capacity to regenerate water while preserving its quality and the capacity to support the user's quality of life, including safety, performance, and his or her psycho-physiological well-being (Karga & Schlacht, 2012).

To preserve a system's sustainability, not only technological factors but also the psycho-physiological well-being of the user are important to support the holistic approach. A human who is not reliable psychologically may make mistakes and disrupt the small and fragile closed-loop system of a Space station (Schlacht et al., 2015b). But thinking holistically about a system does not only mean considering psychological and technical elements, but also the life-cycle perspective at all levels. This will guarantee results that are sustainable in the long term. In this approach, every action is considered in terms of its impact on its surroundings and beyond and its consequences for the well-being of people, land, air, water, plants, animals, and future generations, and their interactions. Moreover, this concept can be applied on different scales: micro (product, service, and process), meso (sector, supply chain, region, and system) and macro (economy-wide) (Iannaccone, 2014 p. 14).

In other words, the design should be holistic and consider all the elements and their interactions in the present and also in the future in order to guarantee optimal quality conditions for the user in relation to the system.

4. How: slow approach to distributed economy and sustainable sensoriality

We know now that for a Space station as well as for our applications on Earth we need to holistically consider all the elements and their life-cycle. We also know that the design approach that supports the user's quality of life is strictly related to the equilibrium of the system (Ceppi, 2012). However, we do not know which design approach we need to use to achieve "sustainable quality".

The slow approach is aimed at guaranteeing the quality of the design approach. For this reason, this approach is the one that is able to support sustainability and the overall equilibrium of the system, applying quality both on Space stations and on Earth. However, what does it imply?

"Above all, the slow approach means the simple, but in current times revolutionary, affirmation that it is not possible to produce and appreciate quality if we do not allow ourselves the time to do so, in other words, if we do not activate some kind of slowdown. However, slow does not only mean this. It also means a concrete way of actually putting this idea into practice. It means cultivating quality: linking products and their producers to their places of production and to their end-users who, by taking part in the production chain in different ways, become themselves coproducers" (Capatti, et.al. 2006 p.4). In a Moon village, this may easily be the case; indeed, in a small system, the relationships among the elements are much more direct and immediate. So, in a small settlement that needs to be autonomous, each astronaut may get in contact with "sustainable quality" to a much greater extent.

"So, the slow approach outlines a new production and consumption model that is at the same time both subversive and feasible. While clashing head on with the ideas and practices of today's prevailing globalisation, it can be enacted locally both immediately and, as Slow Food has proved, successfully.

In our opinion, the great potential of the Slow Food experience needs to be understood better, both in terms of its nature as a strategic project for the development of new food networks and, as is of greater interest to us here, in its more general potential as a contribution to the definition of new ideas on quality, well-being and development models" (Capatti, et.al. 2006 p.4)

5. Future application of sustainable quality to human factors

The holistic and slow concept can be applied to guarantee "sustainable quality" in all sectors related to human interaction. In particular, five Human Factors projects related to Space and Earth applications aimed at achieving sustainable quality are currently in development at Politecnico di Milano under the guidance of Dr. Schlacht and Prof. Ceppi. Below, the topic of each project related to Human Factors is described briefly:

- Psychological & socio-cultural factors: Integrating creative and artistic applications as part of the need for cultural development in the closed loop (project: Creative activity as psycho-social support in isolation).
- Environmental factors: The design is based on direct experience of the minimum closed-loop condition with simulation of place, time and space (project: Empathetic design).
- Operational factors: Collecting the collective lessons learned from previous experiences to design the elements of human interaction in extreme contexts (project: Collective habitability debriefing)
- Physical factors: Investigating body reaction, adaptation and exaptation with different variables, such as the changing of gravity and isolation (project: Movement interaction in microgravity).

In these works, an effort is made to consider Human Factors constructs in order to design sustainable systems using a slow approach and a holistic methodology to achieve sustainable quality (Ceppi, 2006; Schlacht 2015).

6. Conclusion

Future innovations should be developed to meet the requirements originating from the concept of "sustainability quality". This concept aims to establish the basis for implementing quality of life on Earth by transferring sustainable technologies and know-how from Space to Earth using a holistic design methodology and a slow approach. It can have a wide variety of different applications, ranging from food production via eco-building to business practices. Case studies in this context predominantly include recent projects or experiences to improve understanding and encourage implementation.

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Examining Office Type Preference

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Office types and their environmental features influence performance and job satisfaction. Yet employees' opinions are seldom considered when choosing office type. This paper suggests a method that investigates employees' office type preferences and motives behind the preferences. The method proved to be quick and simple and provided a flow of current to preferred office type. A majority preferred the quiet cell office for its privacy while the open office was considered having a noisy and distracting environment and lack of privacy. These factors should be prioritized when planning work environments.

Keywords: Office design, layout, job satisfaction, work environment, method

1. Introduction

Office workers' performance is influenced by office types (Been & Beijer, 2014; Seddigh et al., 2014) and their environmental features (Sundström et al., 1980; Fadeyi & Taha, 2012). For example, studies report that office noise impair concentration (Banbury & Berry, 2005) and speech intelligibility decreases cognitive performance in common office tasks (Liebl et al., 2012; Jahncke et al, 2013). Also, self-perceived efficiency and accuracy vary in different office layouts (Danielsson & Bodin, 2008). Open-plan offices are said to create flexible space for organization and layout restructuring, and saves costs in terms of maintenance. Also positive effects of open-plan offices include better interaction, feedback and social relations (Brennan et al., 2002; Kaarlela-Tuomaala et al., 2009). However, according to Kim & Dear (2013), these effects are small in comparison to the negative effects of decreased privacy and noise level. To overcome these negative effects, while still saving costs, flexible offices, including activity-based workplaces (ABW) have been introduced (Van der Voordt, 2004) and are increasing in numbers in Sweden. Yet Seddigh (2015) concludes that flexible offices are more similar to open-plan offices than to cell offices regarding how they affect their employees.

Moreover office workers' performance is influenced by job satisfaction (Danielsson & Bodin, 2008; World Green Buildning Council (n.y.), and the physical environment is an important contributor to job satisfaction (Brill & Weidemann, 2001).

However, despite these facts environmental features and employees' opinions are seldom considered when contracts are made (Kaarlela-Tuomaala et al., 2009). When choosing office layout, a valuable source of information is the employees' preferences and motives for these preferences as employees have different work environment needs in order to be productive and satisfied. An incentive to overcome this omission is to launch a user-friendly method, possible to use by companies before making office type selection. Besides describing this newly developed method, the aim of this paper is to evaluate an explorative cross-sectional study that maps office workers' preferences and complaints concerning office types.

2. Method

2.1. Participant

The study was conducted with 72 participants during a round table seminar at a work environment fair in Sweden. Approximately 40 % were safety representatives, 10 % worked in

management and human resources, 20 % were occupational health services personnel and 30 % had other mixed backgrounds.

Figure 1. An example of participants answering a question by raising coloured post-it notes.

2.2. Procedure

First, the following question was posed; "What type of office do you occupy today?" The participants raised post-it notes with the colour representing their choice (Fig. 1). The results were documented through photographs from rear and front angles. The procedure was repeated with the question "Which office type would you like to occupy?" Secondly, the participants noted on the first post-it note three aspects they disliked about the work environment in their present office type and, lastly, they noted three reasons for their preferred office type.

2.3. Data Analysis

The post-it notes were counted by current office type and office type preference. Further, the written comments on environmental features were divided by office type and categorized according to a combined model of de Croon's conceptual model on office concepts and work conditions (2005), World Green Building Council's flow chart on health, wellbeing and productivity (World Green Building Council, n.y.) and Sundstrom & Sundstroms' (1986) physical environment model as a component of job satisfaction. Comments representing more than one category were duplicated. The categorization of comments was discussed with five researchers from an ergonomics department to validate the results. Finally, the number of comments was divided by the number of participants from that office type in order to make a statistical comparison.

3. Results

The method took approximately10 minutes to complete for the four questions, and eight photographs were taken as documentation. When the post-it notes were elevated the participants saw each other's responses. The simultaneous elevation hindered peer influence in changing post-it note response. The method generated 57 complete answers. Reasons for participants not responding were that some did not raise any post-it notes or declined writing down answers.

The participants' present distribution between office types is shown in Figure 2. As seen in Figure 3 and Figure 4, cell offices followed by activity based workplaces (ABW)/flex offices, are the most popular office types. The majority of cell office workers wanted to remain in cell offices while the majority of shared room and open office workers wanted to move to other office types. Only one participant wanted to remain in the open-plan offices and no-one wanted to move to this office type. Instead most participants (3/4) preferred cell offices and 1/6 preferred ABW/flex offices. As can be seen in Figure 5 the majority of the present open-plan office workers would prefer cell offices.

The groups of participants currently occupying cell offices and open-plan offices were large enough in order to compare their comments (Fig. 6). The results indicate that open-plan office workers complain about noise and distractions to a higher extent than cell office workers. Most open-plan office workers complained about lack of auditory privacy; being disturbed and difficulties to concentrate due to distractions and coworkers' discussions. Many also complained about acoustics, i.e. high sound level although not specifying source. Some also complained about too much communication, as being disrupted by questions. Other types of privacy, such as being unable to have private conversations, were also commented on. Although cell office workers also complained about acoustics, mainly concerning external sources outside the room, they in contrast complained about physical factors such as indoor air quality, thermal

Figure 2. Participants' current office type.

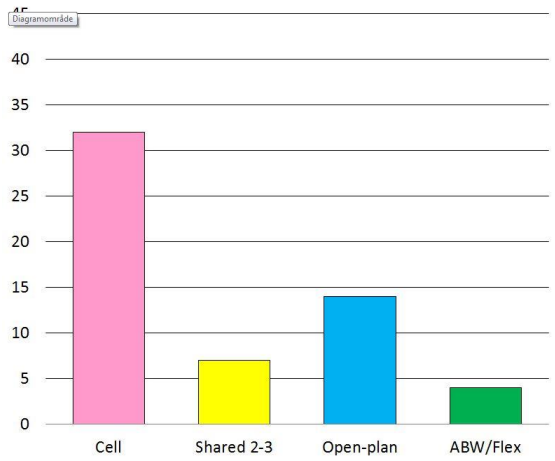


Figure 3. Participants preferring present office (coloured) and those wishing to move to another office type (striped).

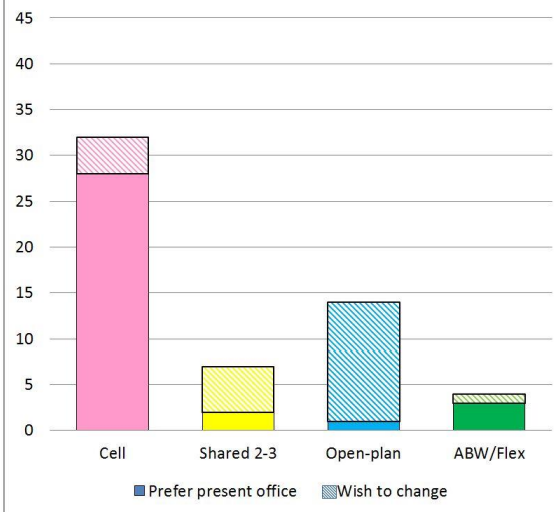


Figure 4. Preferred office type, divided into participants currently occupying the preference (coloured) and participants wishing to move to preference (blank).

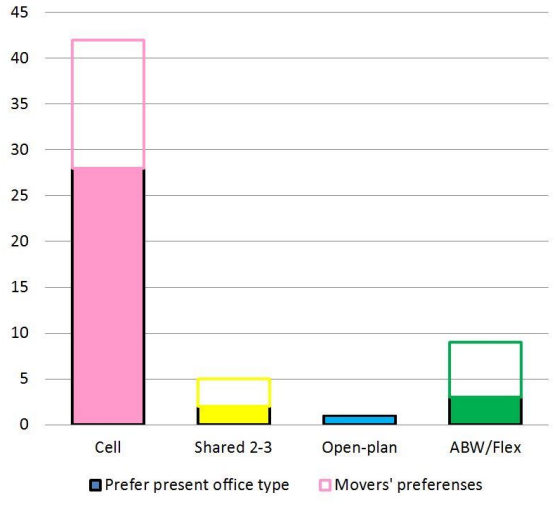


Figure 5. Tracking of participants' current office type into their preferred office type.

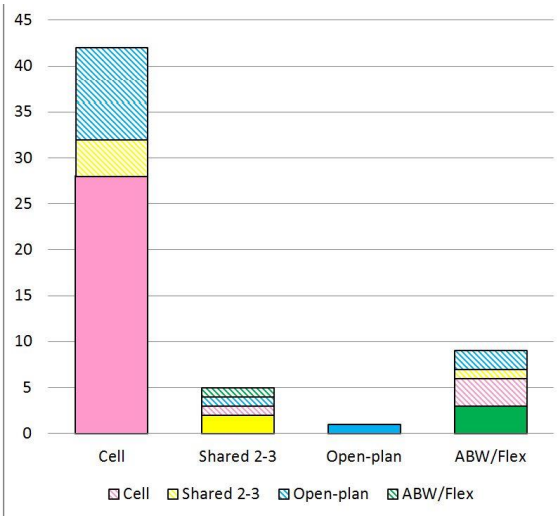
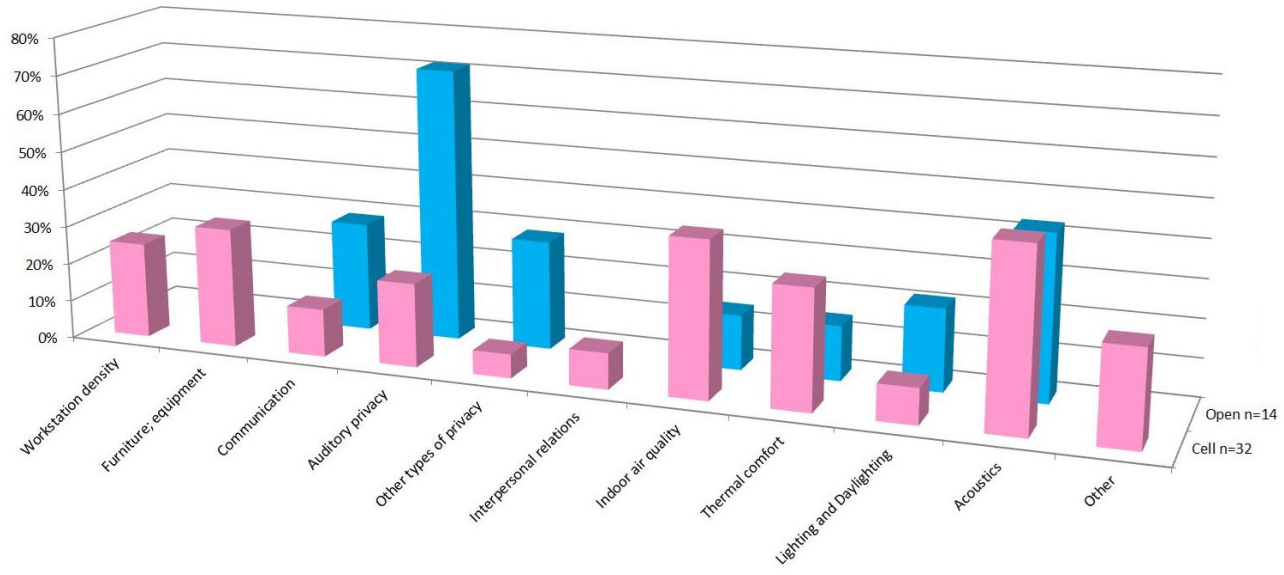


Figure 6. Percentage of cell and open-plan office workers' complaining about environmental features in their current office type.



comfort and furniture/equipment.

Moving on from complaints, cell offices were preferred because of the calm and quiet environment providing few distractions, disruptions and good concentration opportunities, and enabling private conversations.

4. Discussion

Although the same information could be collected through a questionnaire, this method gives instant feedback when elevating the post-it-notes in the air. Since the participants can see each other's choices the inquiry becomes more interesting and they seemed to enjoy it. Instant feedback could, however, be obtained through an audience response systems, so-called "Clickers"; a system where each participant answers multiple-choice questions through handheld transmitter and the results are instantly displayed in a computer/large screen (Bruff, 2009). Nevertheless this system demands obtaining the transmitters and does not allow open-ended questions. Thus our method can be considered both efficient and effective as it requires no advanced tools, only 10 minutes of workers' time and results in both statistics and subjective reasoning. However it should be noted that interpretation errors could occur of the subjective reasoning as brief comments on post-it-notes may not be self-explanatory enough. Also there could possibly be practical difficulties in getting the participants to elevate and face the post-it-notes towards the camera simultaneously. This could partly be overcome by more diligent photographing. Taking pictures from two angles, as done in this case, increases precision in counting responses.

As a method used for mapping office type preference it provides feedback on possible improvements in the current environment and feedforward on preferred environmental features in a future office. These improvements most likely affect job satisfaction and thereby also productivity. Although the data might deal with preconceptions with office types, as everyone has not experienced all different types, the noted comments explain the underlying reasoning for the preference. These extra comments explain the employees' perceived environmental needs in order to thrive at their workplace and could thus be used as a base if the organization cannot, for some reason, chose the employees' preferred office type. In such a case the method should be complemented with observations or other methods for more objective data, and mapping of work tasks.

Recommendations for further investigation are larger sample sizes, especially office workers that are currently occupying ABW and shared offices. The small sample size in this study allows only limited conclusions.

The cell office was appreciated for its calm and quiet environment and complaints mainly concerned external sources of noise and physical factors such as indoor air quality, thermal comfort and furniture equipment. The open-plan office had only one participant arguing its advantages, thus no conclusions could be drawn. However drawbacks could be collected and mainly concerned auditory privacy i.e. noise and distraction, acoustics, too much communication and other types of privacy. The fact that open-plan office workers in this study want to leave their current office type indicates that noise and audial distractions have higher negative impact on office workers than other environmental features. The fact that only one participant wanted to remain in the open-plan office indicates that the negative aspects of open-plan offices drowns the positive aspects. This is in accordance with Kim and Dear's (2013) conclusion. However this individual participant's dissimilar preference may be due to his work tasks. Seddigh et al. (2014) concluded that employees with concentration demanding tasks are more disturbed in all office types except cell offices. Possibly, many employees mainly work with concentration demanding tasks thus want a distraction free environment.

While the cell office provides work conditions that facilitate concentration, open office workers must, due to the open office conditions, increase their effort in order to perform their tasks efficiently. Thus it is perhaps not possible to expect unchanged or improved work performance when moving employees to open-plan offices if they mainly work with

concentration demanding tasks. It is therefore important to also investigate work tasks when choosing office type.

4. Conclusions

In conclusion, a quick and simple method capturing employees preferences regarding office type and environmental features is proposed. It presents immediate feedback to both employees and management, useful for making improvements in current work environments and in planning new facilities.

The study indicates that the cell office and the open-plan office are the most versus the least preferred office types. One reason is that the former provides privacy, especially auditory privacy, while the latter does not. Thus, noise prevention and auditory privacy need higher priority when choosing office type, especially for concentration demanding work tasks.

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Nature contact at office work places and organizational support: benefits on stress reduction, subjective health complaints, and sick leave

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Based on a cross sectional questionnaire survey, the present study explores the relationship between indoor and outdoor nature contact at office work places and related health outcomes. Possible benefits of nature contact are discussed both in relation to nature restoration theories and organizational support at work.

Keywords: worksite health promotion, occupational health research, indoor plants, window view

1. Introduction

Nature interventions at work places have increased in popularity in the recent years. However, few studies have examined potential benefits of this on health and well-being, and even fewer studies have explored possible explanations for the assumed advantages for health. One likely explanation for the benefit of nature contact during work is based on theories that nature contact generally provide a potential for mental restoration through reduced stress level (Ulrich et al. 1991) and restored depleted attention (Kaplan & Kaplan 1995). Other explanations for why nature contact at work can promote health is related to the general significance of social support at work (Eisenberger et al. 2002; Karasek & Theorell 1990). In an office work context the physical environmental design, including window view to nature and interior plants, and freedom to visit outdoor nature during breaks, can be experienced as being taken care of and appreciated by the employer.

2. Objectives

The objective of the present study was to investigate whether nature contact at work is associated with office employee's health, and to study whether the possible associations between nature contact and health can be explained by theories on nature restoration or by perceived organizational support. A direct relation between nature contact and the measured health outcomes was hold to support the theories of nature restoration, whereas a mediating effect of organizational support was hypothesized to support the role of organizational support in the relation between nature contact and health.

3. Methods

Data were collected through a web-based, cross-sectional survey of employees in seven public and private office workplaces in Norway (n=707, 40 % response rate). Nature contact was measured by the Nature Contact Questionnaire developed by Largo-Wight and colleagues (2011), measuring both indoor and outdoor nature contact. Indoor nature contact was defined as contact with natural elements inside a building such as live plants, natural light and windows with a view to the outside. A single question was added about the extent to which the view from the office window(s) featured natural or built elements. Outdoor nature contact was defined as being outdoors in nature environments for purposes such as errands or lunch breaks during working hours. Perceived organizational support was measured by a sub-scale from the QPS-Nordic (Lindström et al. 2000). Outcome measures were perceived job stress, measured with a Norwegian version of the Job Stress Survey (JSS-N) (Spielberger & Håseth 2004), subjective health complaints, measured with Subjective Health Complaint inventory (SHC) (Eriksen et al. 1999) and sickness absence, measured by two questions made for the purpose. Multiple linear and logistic regression analysis were performed on 565 participants. To check possible mediating effects through perceived organizational support, the regressions were repeated while controlling for perceived organizational support. Sobels test was utilized to test whether the indirect effect of nature contact on the health outcomes via the mediator perceived organizational support was significantly different from zero.

4. Results

A greater amount of indoor nature contact at work was significantly associated with less job stress, fewer subjective health complaints and less sickness absence. Perceived organizational support mediated the associations between indoor nature contact and job stress and sickness absence, and partly mediated the association with subjective health complaints. This supports the explanation of health benefits of nature contact at work being related to the perceived organizational support. The fact that the relationship between indoor nature contact and the health outcomes could be explained by the mediating effect of organizational support was interpreted as not supporting the theory of restoration by nature contact as such. However, the mediating role of factors expected to cause stress reduction or attention restoration according to nature restoration theories were not examined in the present study. Outdoor nature contact showed no reliable association with the outcomes in this study. The presence of positive results only for indoor nature contact and not for outdoor may rely on the cultural context and how the work day is organized.

Results from the study are presented in details in the upcoming special issue "Workplace-based efforts in promoting health and preventing disability in Norway" in the journal WORK, A Journal of Prevention, Assessment & Rehabilitation (Bjørnstad et al. in press).

5. Conclusions

Introduction of nature indoors at the office work place can be used as possible health-promoting interventions. However, given the mediating effect of the sense of being taken care of by the staff, the present study concludes that nature based interventions at work

places should not be seen separately, but must be understood as part of the total social climate at the workplace, and especially the organizational support.

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Enhancing safety and productivity in fully mechanized forest operations; workload influence on operator performance

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Abstract

Operating forestry machines requires coping with the pressure to achieve high productivities while performing similar movements for consecutive hours. Working in monotonous environment often causes lack of concentration or unbalanced mental workload. Our research investigates the relations between performance, conditions and mental workload using objective and subjective measurements. These methodologies widely applied in other fields have not yet become known in the forestry sector. Workload, job stress, hard working conditions and recruitment are among some of the forestry workforce issues which could benefit from the results of our research.

Keywords: Forest harvester, mental workload, productivity, safety

1. Introduction

Modern forest machines (harvesters) have one of the most complex operational interfaces of any industrial production system, with more than 10 electro-hydraulic operations on each joystick, and around 3500 activations per hr. necessary in maintaining an acceptable production rate (Gellerstedt 2002). The operator must select, fell, process into logs of differing value, quality and dimension, about 2 trees per minute, over an 8-10 hr. working day. They must take regard of new price matrices and quality requirements which can be updated via the GSM network multiple times per day. In addition, they must continually navigate the machine through extreme terrain, take regard of important biotopes, boundaries and cultural heritage sites, and avoid damage to the soil, while maintaining a full awareness of safety issues and the falling direction of the trees.

Forest work is known to be one of the most demanding occupations from a physical, organizational and safety point of view. It is associated with numerous health affecting issues related to the implementation of the majority of the specific tasks necessary when harvesting, in addition to exposing the workers to adverse environmental factors while at work. The combination of these factors have initiated considerable research worldwide which aimed at identifying unsafe behaviour and possible patterns in the occurrence of accidents, and at increasing the level of safety during forest work.

Operating and maintaining the new high proficient forestry machines requires specific skills and continuous concentration; both terms have a strong influence on the operations efficiency and safety. Results of our previous research on the improvement of operator performance through training gave us preliminary understanding on the cognitive difficulties of operating rather simple joystick-like controls for a tower yarder (Aalmo and Talbot 2014). The multifunctional features of modern harvesters entails assets such as sufficient computer skills and round-the-clock situation awareness. As

explained by Gellerstedt (Gellerstedt 2002) operating a harvester is a highly complex activity which requires the implementation of simultaneous hand movements to execute the often overlapping functions. Time pressure is omnipresent because of the numerous micro-decisions needed in order to perform the work and the requirements for a minimum production per day. This usually results in an excess of cognitive activities which could degrade the concentration of the operator leading to negative outcomes.

The forest machine operator efficiency is highly correlated to his own well-being both in terms of workload (so health) and safety (Konz and Johnson 2000, Nicholls, Bren et al. 2004). An unbalanced physical and/or mental-workload, has a big impact not only on the system's productivity but also on the safety of the man employed in the operations; the risk level of the tasks performed is relatively high therefore the attention has to be constant because any distraction could lead to serious accidents (Lilley, Feyer et al. 2002). The concept of mental workload is wide and multifaceted, it can generally be defined as the *"operator's evaluation of the attentional load margin (between their motivated capacity and the current task demand) while achieving adequate task performance in a mission-relevant context"* (Meshkati and Hancock 2011). Generally low to moderate levels of mental workload go with acceptable levels of operator performance while high levels are associated with an increased information processing demand and lead to lower levels of operator performance (Wilson and Eggemeier 2006). Mental workload assessment is essential in the R&D of human-machine interactions in order to achieve higher levels of efficiency, and safety in the workplace. Regulating task demands so that they neither under-load nor overload an individual is important to ensure long-term productive efficiency of the operators in addition to increase operation safety, comfort, and consequently improve health.

2. Objectives

The overall aim of this research is to investigate using subjective and objective measurements, how working conditions affect mental workload and which mental workload-overload repercussions there are on system productivity. More specifically we aim at assessing:

- The relation between forest machine operator mental workload and productivity
- The relation between subjective criteria and objective criteria for mental workload evaluation

3. Material and methods

3.1. Participants

Six healthy operators were selected among a larger group of trained workers. The selection process focused on having as much variability as possible in age and years of experience while we tried to select operators driving the same type of harvesting machines (size and technology/brand). The operators willingly agreed to be part of the study.

Subjective workload measures

These assume that the direct relationship between increasing effort and its perception can be correctly assessed by the individuals tested. Among different and valuable methods, the NASA TLX was selected because it is a multidimensional method which is able to assess the components of the mental workload characterizing the experimental task. Additionally it seems to better accepted by the participants (Stanton, Hedge et al. 2004). The NASA Task Load Index (Hart and Staveland 1988) is a workload evaluation tool which accounts for within-task differences between participants, and between-task differences in the sources of the workload and uses six subscales to assess mental

workload: mental demand, physical demand, temporal demand, performance, effort, and frustration. Each of these subscales was described in detail and presented to the tested subjects before they undergo the test.

3.2. *EEG-based workload measures*

The heart rate and its variability were measured to assess the level of workload using Firstbeat Bodyguard2® (Firstbeat 2015) a small and reliable ECG device with continuous data logging and storage. This device has been successfully used to collect data for similar studies in previous research. The operators were wearing the device continuously; the device was taken off only when they were washing. Usually the heart rate variability is analysed with respect to two frequency bands of the power spectral analysis, the MF (0.04-0.15 Hz) and the HF (80.15-0.4 Hz)(Malik and Camm 1990). The HF component reflects cardiac vagal (i.e., parasympathetic) activity, while the LF component is associated with baroreflex activity (Casadei, Cochrane et al. 1995). RMSSD and pNN50 are closely related to the HF component of the power spectrum and thus, are strongly associated with cardiac vagal activity, reflecting a parasympathetic influence. Parasympathetic nerve traffic enacts its effects at a much faster (<1 second) rate than sympathetic outflow (>5 seconds); therefore, beat-to-beat changes in RR intervals (rMSSD) are considered a reflection of vagal outflow (Kleiger, Stein et al. 2005). The heart rate variability was therefore assessed with RMSSD (root-mean square differences of successive R-R intervals) in order to mitigate the observed difference in age between subjects (Reardon and Malik 1996). The total working time for each day was divided into the different activities performed, only the driving/operating part was considered in the analysis. In this study we focus on the analysis of the heart rate variability in the time domain.

3.3. *External conditions*

The environmental conditions of the harvesting site were recorded daily in addition to the production/day (m3/day). Additional parameters were concerning the forest density, the machine type and age, the terrain bearing capacity, the terrain hindrance and steepness, the weather condition, the amount of hours of light and the amount of under-vegetation in addition to the number of assortment and which type of operation was performed whether it was a clear felling or thinning.

Results

Being this study part of a bigger project, only preliminary results on two of the six subjects are presented in this extended abstract. All the data were analysed with R software package. Analysis of variance (ANOVA) test was used to investigate if the perceived rating of workload level were significantly different for the different conditions. The independent variables included thinning/clear felling, terrain hindrance, under vegetation, number of assortments and daily productivity. All values are given as mean value ± SD. A p value < 0.05 was considered statistically significant.

For the subjective rating the average of the rating were used (raw tlx test). After five hours of continuous work the operators were asked to assess their perceived workload. Additionally the individual performances of a whole working day were recorded. As shown in fig 1 (left) the subject occupied with the thinning showed a lower value of the perceived workload (tlx) and lower production per day than the one occupied with the clear felling who produced more. On the right side it is shown the rmsSD per day in the two different operations, an increased workload (higher production and high perceived rating) seems to be associated with a decrease in rmsSD in fact, the rmsSD for thinning resulted 29.7±6.2, while for clear felling was 17.9±5.1.

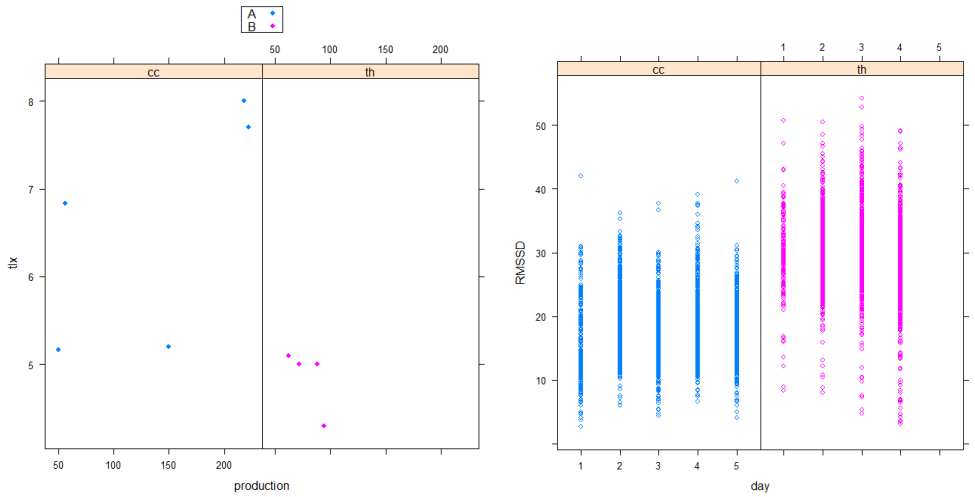

Figure1. Comparison of perceived workload, production (left) and rmsSD (right) per subject and day

Discussion and conclusions

The advantage of this methodology including both physiological and subjective measures, which to our knowledge has never been used in a forestry related context, is that it is non-invasive and highly reliable, and considers subjective and objective measurements precisely. Additionally it presents potential for becoming the basis for the development of safety guidelines not only in relation to operating forest machines such as harvesters but also other type of heavy machines. A further application could be to extend the test to forwarder operators (extraction of timber to roadside) and possibly cover the whole transportation chain with the inclusion of timber-trucks drivers. In the latest application a higher social impact could be expected in the avoidance of accidents on public roads.

This is an exploratory study, and is limited by the relatively small sample size, and the use of time-dependent, not frequency dependent HRV measures. We plan to validate the data in larger numbers using frequency-dependent measures, including low frequency power (LF), high frequency power (HF), LF/HF ratios. Additional analysis will be performed on the other environmental parameters such as tree density, under vegetation, terrain hindrance and light conditions. The subjects showed in fact increased perceived workload to the increased level of under vegetation. We expect to find a correlation also between mental workload and day-light conditions once the data collection will be completed.

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Difference between normative and descriptive concepts on the evaluation of accident narratives

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Accident investigations are important tools in increasing industrial safety. In this paper we report an experiment evaluating the effect of evaluative concepts such as adjectives and adverbs from maritime accident narratives. We hypothesized that purely descriptive accident narrative would lead to more positive evaluations involving less blame against the involved person. An interaction effect indicated that descriptive narrative where more favourably evaluated than the normative narrative on questions involving the ability to understand the reasons and actions. The opposite was found for evaluations not involving questions on 'understanding', thus indicating a differential effect of evaluative concepts in accident narratives.

Keywords: Accident investigations, subjective evaluation, blame, narratives,

1. Introduction

Accident investigations and narratives of accidents and incidents are vital for the understanding of accident causality (Dekker, 2014) as well as for the prevention of accidents (Strauch, 2002). People often make evaluations of the actions and personnel involved in accidents. It is important to understand *if* and *how* the framing/description of accidents can affect the perception and evaluation of the incident, as this might impact on the overall evaluation of causality and on subjective responsibility for the actors involved. There are two ways to make these evaluations in written language – normative evaluations and the use of adjectives and adverbs that modify the valence of nouns and verbs in a sentence.

Normative evaluations. Normative evaluations of human actions are common (*e.g.* "*he conducted an error*"), and the attribution of subjective guilt and blame will often follow as a function of this normative labelling (Dekker, 2007). Examples such ethical/moral judgements are the normative labelling of some behaviour as "human error" (Reason, 1990), or as "complacency" (Parasuraman, Molly & Singh, 1993) or as "lack of situation awareness" (Dekker & Hollnagel, 2004).

Modifying adverbs and adjectives. Other evaluative concepts in accident investigations are adjectives and adverbs that modify nouns or verbs to describe the degree to which a verb or noun have a specific quality (e.g. 'high', 'long' or 'heavy'). For example, Harris (1973) tested the effect of different antonymous adverbs (e.g. "high" vs. "low" as in "*How ….. was the plane flying*"?) and adjectives (e.g. "hot" vs. "cold" as in "*How ….. was the temperature on his birthday*"). The findings showed that the choice of modifier clearly affected the estimates of different qualities – even though the context and the rest of the question were identical.

Loftus and Palmer (1974, experiment 1) evaluated the effect of wording of questions on the memory and understanding of accident scenarios. They showed a group of students a video of a car accident. Afterwards then verbally asked the students to estimate how fast the cars where going when they "smashed"/ "collided"/ "bumbed"/ "hit"/ or "contacted". A clear relationship between adverbs and estimated speed was seen with the adverbs indicating a more violent collision leading to a higher speed estimate ("smashed" = 40.5 mph, "collided" = 39.3

mph, ”bumped” = 38.1 mph, ”hit” = 34 mph and ”contacted” = 31.8). Thus, wording of questions affect peoples’ opinion and evaluation of accidents.

Other similar research has shown that the wording of questions also can affect people´s memory and recollection of events (Loftus, 1974, 1975; Loftus & Palmer, 1974 experiment 2). Thus, it seems that wording and how events are described are of importance for our understanding and evaluation of things such as accidents. However, according the authors’ understanding there seem to be no research papers on the effect of language used in accident reports. Henceforth, this paper seeks to investigate the effect of removing evaluative concepts like adjectives and adverbs from accident narratives.

1.2. Research Questions

This paper seeks to test whether there are differences between “normative” accident narratives (e.g narratives with adverbs and adjectives) and “descriptive” accident narratives (e.g. narratives without adverbs and adjectives). The research question is: “*How do the presence of evaluative concepts in written accident narratives affect the perception of the involved person´s actions and their subjective blame.”* We expect that purely descriptive narratives will lead to more positive and less judgemental evaluation of the involved person´s actions.

2. Method

2.1. Experimental design

The experiment was designed as a 2 x 2 split-plot repeated measures experiment. Accident narratives 1 and 2 were within-subject variables and type of accident narrative (normative vs. descriptive) was between subject variable. Participants answered 6 questions to each narrative. Hence, the research question could be answered by a between-group analysis of variance.

2.2. Accident Narratives

Two maritime accident narratives taken from actual accident investigation reports were used (AIBN, 2012; AIBN, 2013). The original text from the accident investigations was used as the normative text (with adjectives and adverbs) while removing all adjectives and adverbs from the text created the ‘descriptive’ text. The first accident narrative (AIBN, 2013) involved a machine engineer on a vessel who fell down from a ladder and hit his head. He was immediately given first aid and was later flown to hospital with a helicopter.

Table 1. Accident narrative 1 – Falling off a ladder

Normative	Descriptive
I forbindelse med en rutinemessig rengjøring av et lasterom, falt en motormann stygt ned fra en høy stige og slo hodet hardt mot tanktoppen. Vernehjelmen var ikke festet med den tilhørende hakestroppen, hjelmen falt derfor av rett før han landet ved bunnen av stigen. Undersøkelser viser at motormannen selv fjernet en påkrevd sikkerhetsline umiddelbart før fallet. Det er sannsynlig at motormannen koblet fra den påkrevde sikkerhetslinen fordi hank an ha opplevd å ha full kontroll på situasjonen og lav grad av opplevd risiko for fare så langt nede i stigen. Fjerning av sikkerhetslinen medførte også en mer bekvem klatring. Fallet var fra en slik høyde, omtrent en meter, at motormannen ble slått bevisstløs umiddelbart etter sammenstøtet. Førstehjelp ble iverksatt øyeblikkelig, og den skadde ble fraktet hurtig til skipets hospital, hvor behandlingen ble overtatt av medisinsk personell. Kort tid etter ble den skadde fraktet med helikopter til sykehus.	*I forbindelse med rengjøring av et lasterom, falt en motormann ned fra en stige og slo hodet mot tanktoppen. Hjelmen var ikke festet med hakestropp og falt av rett før han landet. Undersøkelser viser at motormannen fjernet en sikkerhetsline før fallet. Det er sannsynlig at motormannen koblet fra linen fordi han opplevde å ha kontroll på situasjonen. Fjerning av linen medførte også en bekvem klatring. Fallet, fra omtrent en meter, førte til at motormannen ble slått bevisstløs. Førstehjelp ble iverksatt og den skadde ble fraktet til skipets hospital, hvor behandlingen fortsatte. Senere ble den skadde fraktet med helikopter til sykehus.*

The second narrative (AIBN, 2012) involved a sightseeing trip to a glacier, which was part of a polar cruise. When the boat was close to the glacier the front of the glacier calved (i.e. large chunks of ice breaks off the front of the glacier) and ice hit firm ground thus being scattered violently across the area. One passenger was hit in the head and neck by ice. The boat had been about 100 meters from the glacier when it calved, and the stated safety zone was set to 200 meters.

Table 2. Accident 2 – Hit by Ice

Normative	Descriptive
Passasjerer og guider fra et større cruiseskip i polare farvann var på en vanlig dagsutflukt med lettbåtene sine innerst i en fjordarm. Mens d små lettbåtene var i nærheten av en stor isbre kalvet store deler av brefronten. Ismassene traff fast grun med høy fart og isklumper ble kastet ukontrollert i alle retninger utover det lille området med voldsom kraft. En av passasjerene om bord i en av de små lettbåtene ble truffet av flere isklumper i nakke og hoderegion.	*Passasjerer og guider fra et cruiseskip i polare farvann var på en dagsutflukt med lettbåter i en fjordarm. Mens lettbåtene var i nærheten av en isbre kalvet deler av brefronten. Ismassene traff fast grunn og isklumper ble kastet utover området. En av passasjerene om bord i en av de små lettbåtene ble truffet av isklumper i nakke og hodet.*
Guidene og passasjerene var fullt klar over at det kunne oppstå en kalving av den store brefronten og at denne kunne treffe fast grunn, men de var antageligvis ikke forberedt på at kalvingen ville bli så voldsom og kraftig. Reiseoperatørens klare instruks til guidene var å holde en trygg avstand på minimum 200 meter til brefronten, det anslås at avstanden ved ulykkestidspunktet bare var omkring 100 meter.	*Guidene og passasjerene var klar over at det kunne oppstå en kalving av brefronten og at denne kunne treffe fast grunn, men de var ikke forberedt på at kalvingen ville bli så kraftig. Reiseoperatørens klare instruks til guidene var å holde en avstand til brefronten på 200 meter, det anslås at avstanden ved ulykkestidspunktet var omkring 100 meter.*

2.3. Questionnaire

Participants answered a number of questions involving 'it is easy to understand the behaviour', 'it is easy to understand why the person did as he did', 'the involved person should have predicted the occurrence of the accident', 'the actions in the event were acceptable', 'the person showed good seamanship', and 'the person was singularly responsible for the accident'. Participants answered these statements with a 7-point likert scale where 1 indicated 'agree' and 7 indicated 'disagree'. Hence, a relatively higher score on a question will indicate a more negative and judgmental evaluation of the event and the involved person.

3. Results

A 2 (type of story) x 6 (questions) General Linear Model with repeated measures was calculated using IBM SPSS 22. A total of 102 (86 men and 14 women) students and employees at Buskerud and Vestfold University College aged 20-42 years of age (M = 24.2, SD = 4.68) participated in the study. Characterisation of effect sizes as 'small', 'moderate' or 'large' follows Cohen´s (1988) classification of effect sizes.

Results indicate a very small and insignificant difference between the marginal means of the normative (M = 3.87, 95% CI [3.67, 4.08]) and the descriptive (M = 4.02, 95% CI [3.81, 4.22]) narratives ($F_{1, 100}$ = .954, M_{diff} = 0.143, 95% CI of M_{diff} [-0.148, 0.434], p = .331, d_{av} = 0.01). Hence there was no overall effect of removal of evaluative concepts in the accident narratives. This was in direct opposition to our initial hypotheses – as we expected that people would be less appreciative (e.g. score higher) on the normative narratives

An interaction effect of small size was observed between type of narrative and questions were present ($F_{5, 500}$ = 3.857, p = .028, Eta_p^2 = .025) and this probably stemmed from the tendency that the questions containing "understanding" where answered more negatively for the normative narrative than for the descriptive narrative. For the remaining four questions the result was the other way around. The data can be seen in Table 3 that also show tests for differences between individual questions. Systematic differences (e.g. differences where the

95% CI did not include 0) of medium size between the narratives where observed for questions "The actions where acceptable" and "showed good seamanship" where the descriptive narrative scored higher – e.g. more negative. This was not in accordance with our expectations.

Table 3: Differences between Normative and Descriptive Accident Narratives

	Descriptive (N = 50)		Normative (N = 52)		Difference		
	M	95% *CI*	*M*	95% *CI*	M_{diff}	95% *CI*	d_{av}
It is easy to understand the actions	3.85	[3.42, 4.28]	4.19	[3.77, 4.61]	-0.34	[-0.94, 0.25]	0.23
It is easy to understand the reasons for these actions	3.39	[2.97, 3.81]	3.68	[3.26, 4.1]	-0.29	[-0.88, 0.29]	0.20
Should have predicted the incident	2.23	[1.91, 2.55]	2.14	[1.88, 2.41]	0.09	[-0.32, 0.5]	0.08
The actions where acceptable	5.22	[4.89, 5.56]	4.68	[4.33, 5.03]	0.54	[0.06, 1.02]	0.44
Showed good seamanship	5.75	[5.46, 6.04]	5.29	[4.97, 5.61]	0.46	[0.03, 0.89]	0.43
Alone to blame for the accident	3.65	[3.14, 4.16]	3.24	[2.84, 3.64]	0.41	[-0.23, 1.05]	0.25

Note: *M* = Mean, 95% CI = 95% confidence interval, M_{diff} = Mean difference, d_{av} = Cohen´s delta with average standard deviation ((SD_1*n_1 + SD_2*n_2)/(n_1+n_2)) as denominator (Lakens, 2013). Systematic differences are found where the CI does not contain 0 ('zero'). Please note that a high score means ("I disagree"), hence being indicative of a less appreciating opinion (e.g. the participant has a more negative evaluation of the person involved in the accident).

To further investigate the reasons for the observed interaction effect we aggregated the two questions pertaining to "understanding" into sum scores for the two narratives. This was done because questions relating to "understanding" can be seen as indicative of the same psychological constructs empathy and ability to see things from other´s perspective. We found that the descriptive narrative (M = 6.37, SD = 3.13) where more favourably evaluated than the normative narrative (M = 8.75, SD = 3.38; t_{101} = -7.31, M_{diff} = -2.38, 95% *CI* of M_{diff} [-3.03, -1.74], d_{av} = 0.72). The effect size d indicated a moderate to large effect size. We did not aggregate the other four questions as they seemingly measure different aspects of the same event (seamanship, blame, acceptability of actions, and prediction) and hence could not be seen as aspects of a single construct.

4. Discussion

The way that accidents are described in accident reports or in conversations can impact on the evaluation of the involved persons and actions (Loftus, 1975; Dekker, 2005). We therefore compared two narratives (one normative and one descriptive) of the same incidents. We did not find support for the initial assumptions that purely descriptive narratives of accidents would be evaluated in a less judgmental way. On the contrary –to the extent that there was an overall effect - we found that purely descriptive narratives led to slightly less favourably evaluations (M = 4.02) than for the normative narratives (M = 3.87), however, this difference was very small and was not statistically significant.

An interaction effect where also present, and further post-hoc analyses showed that that questions pertaining to understanding were more positively evaluated by the people who read the descriptive narrative as compared to the normative narrative. A possible explanation for this effect is that the questionnaire where partly covering questions on the participant´s ability to understand the actions and reasoning, *i.e.* it involves the candidates ability to see the situation from another persons perspective (a type of 'internal evaluation'), while the other questions involves a more direct and the participants evaluation of some other person (i.e. a type of '*external evaluation*'). However, these indications have come as a result of post hoc evaluation of the data and can only be seen as an indication – but not as evidence for such an effect.

4.1. Limitations

Participants of this study were mainly maritime students and employees, and the accident cases were also from the maritime domain; hence reducing the generalizability of this result to the other industries.

We also removed all adverbs and adjectives – irrespective of how they modified valence. This is an experimental weakness as valences can go both ways (Harris, 1973). So, by

removing both positive and negative modifiers we probably reduce the effects that could be observed. This may explain the relative lack of systematic results.

The observation of the main effects reported in this paper is based upon post-hoc analyses and hence is not evidence for such an effect. It merely can be used to generate hypotheses that can be directly tested in new experimental research.

5. Conclusion

There seems to be no general effect of adding or subtracting evaluative concepts from a written narrative of an accident. However, for questions relating to the evaluation of actions external to the evaluator a purely descriptive narrative was found to lead to slightly more negative evaluations than the normative narrative. The opposite was found for questions asking about whether the evaluator found the actions and/or reasons understandable ('internal' evaluation) the descriptive narrative gave much more positive evaluations. This might indicate a differential effect of evaluative concepts in accident narratives. However, this test was done post hoc and requires new experiments to be properly evaluated.

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Comparing 2D and 3D models as tools for evaluation of workplaces

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The aim of this paper is to present a comparison between 2D and 3D models as tools for evaluating workplaces. The comparison focus on different given in the comments when evaluation with 2D and 3D models. The results make strong indication that overall layout, line of sight and space are perceived differently in 2D and 3D models.

Keywords: 2D models, 3D models, User input, Design evaluation

1. Introduction

The benefits of evaluating a product or workplace design with users before implementation are well known. This is generally achieved by introducing users to various kinds of models, from paper drawings to mock-ups or fully working prototypes, and with different levels of detail. Often, the issue at hand for product developers is what kind of model to use and when to use it during the development process, and to do this in a manner that makes optimal use of resources such as time, money and personnel. Also, different types of models used in the evaluation may return different in feedback. For example, Boothe et al. (2013) compared two user interface models with different fidelity and the results showed that users were able to identify more usability problems with the higher fidelity model.

One interesting aspect worth exploring is whether there is any difference in the design feedback gained from 2-dimensional and 3-dimensional models. In cartography, Herbert and Chen (2014) found that 3D visualisation appeared to improve the planners' mental images of proposed buildings and that 3D was considered more useful for undertaking complex assessment tasks. A study by Iqbal and Hashmi (2001) found that 3D virtual environments allowed a better perspective of what could be achieved in the re-design of a factory layout.

The aim of the present paper is to present a comparison between 2D and 3D models as tools for evaluating workplaces. The present comparison focuses on differences in feedback comments given based on evaluation with 2D and 3D models. This comparison is a part of a larger main study and other parts have been presented in Österman et al. (2011) and Bligård et al.(2014).

2. Method

Six focus groups were shown several different model representations of a ship bridge and asked to evaluate the design with respect to work environment and workplace efficiency, i.e. the possibility to perform tasks in a safe and effective manner. Each group consisted of three nautical cadets in their third or fourth year at a Swedish merchant marine academy. The ship

bridge was presented in four different ways: as a two-dimensional (2D) paper drawing, as a three-dimensional (3D) model in a CAD program, as a 1:16 foam-core board model, and as a 1:1 plywood mock-up (Figures 1-4).

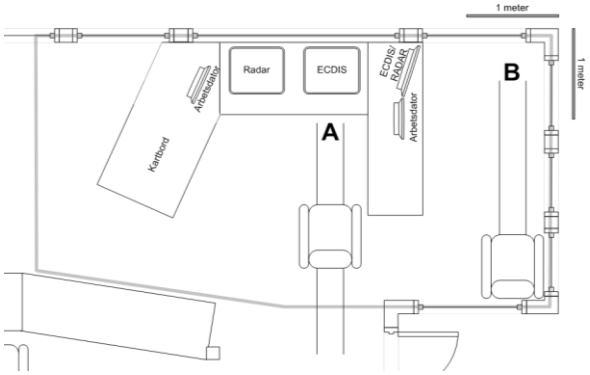

Figure 1. Example of a 2D- drawing

Figure 2. Example of a 1:1 model

Figure 3. Example of a scale model (1:16) made of foam-core board

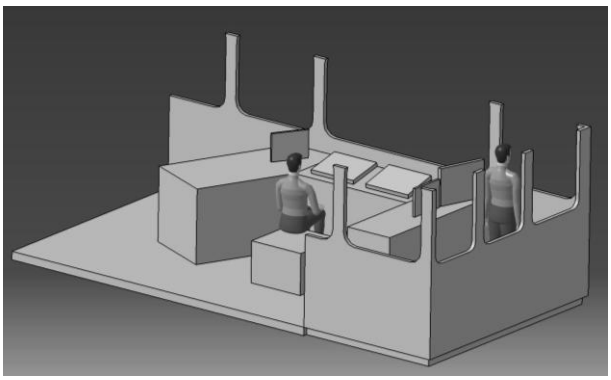

Figure 4. Example of a CAD-model (Computer Aided Design)

In a use scenario workshop (cf. Broberg, 2010) featuring three different work scenarios (during mooring, operating in a busy fairway and performing a specific work operation on deck), the cadets gave feedback on each of the representations. The scenarios were first responded to individually in a questionnaire, and later orally in focus groups. Each group was first shown the 2D representation, followed by the three 3D representations in different successions for each focus group.

Each group session was introduced by one of the researchers, explaining the plan for the session and the use scenarios. Following this, each participant was encouraged to interact freely with each representation by physically manipulating and testing it in a suitable way, in order to trigger evaluative responses to each use scenario. The individual written feedback was collected and the group discussions were documented with both audio and video recordings.

The written questionnaire responses were transferred to a digital spreadsheet, and the audio and video recordings of the group interviews were transcribed verbatim. Coding analysis was performed on the transcripts and questionnaire data by all three authors in parallel. A qualitative data management software was used to manage, code and analyze the data collected from the six focus groups (Dedoose, 2015). This coding process involved several iterative cycles of coding by each author, discussions in the group to reach consensus on the choice and consolidation of codes, and note-taking to capture additional insights during the analysis process. The analysis was of both a qualitative and semi-quantitative nature, using established coding practice and some built-in functionality of the Dedoose software tool, respectively.

3. Results and analysis

3.1 Semi-quantitative analysis

The semi-quantitative comparison between the 2D and 3D models was able to demonstrate relative differences in feedback regarding the amount of instances coupled to a certain design aspect. It should be carefully noted that the "number of codes" presented in Tables 1 and 2 are not absolute measures in any way, but as far as possible the research team made sure that all agreed on the coding of each qualitative fragment's content and extent. Thus, what should be noted is the relative difference between them.

Table 1. Number of coded instances per model (for comparison)

	2D	1:1	1:16	CAD
Questionnaire	511	200	156	89
Focus group	401	266	196	116

One preliminary methodological caveat was that the 2D representation was consistently presented first for each focus group, garnering a larger amount of comments in total compared to the 3D-models. This design was intentional as the larger study aimed to compare the relative merits of the 3D models, thus it was useful to "pre-empt" the participants' first impressions of the design using a drawing, which they were familiar with. If there were still very many comments when the 3D models were presented, this was most often due to participants gaining new insights about the design on seeing a different model representation. More comparatively, the authors identified the top 5 codes regarding functional design feedback on 2D and 3D models from the participants (Table 2).

Table 2. Functional design comments (with all 3D model comments summed up)

#	**2D**	**Σ3D**
1	Line of sight (125)	Line of sight (96)
2	Working with computers (46)	Related to body (55)
3	Experience / anecdote (44)	Movement (45)
4	Movement (30)	Experience / anecdote (40)
5	Related to body (30)	Operator interaction (28)

The main functional design aspect commented in the both 2D and 3D-models was the line of sight, which indicated that this is a important factor for evaluation of a ship bridge, but also a strong indicator that the participants re-evaluated the visibility conditions when confronted with the 3D-models. To a higher extent than for 2D, participants related the 3D-models to the body size of potential users (like themselves) and the physical movements made on the bridge in the scenarios.

For 2D, more focus was on working with computers and relating experiences / anecdotes during the evaluation. Overall, the 3D-models seem to have mediated greater focus on the users' physical presence on the bridge. The authors also compared which physical design elements (chairs, displays etc.) were most commented on (Table 3).

Table 3. Physical design comments

#	**2D**	**Σ3D**
1	Displays (88)	Displays (111)
2	Overall layout (79)	Space (86)
3	Controls / Instruments (50)	Chairs (80)
4	Chairs (50)	Overall layout (58)
5	Tables/panels (37)	Tables/panels (55)

The main physical design aspect commented in both the 2D and 3D-models concerned displays, often in connection with discussions regarding line of sight (see Table 4). However, the high numbers for the 3D representations also indicate that the participants re-evaluated the display conditions when confronted with the 3D-models. To a higher extent, participants related the 3D-models to the space on the bridge and placement of the chairs, something which was less pronounced in 2D where the height dimension was missing. For 2D, more focus was on the overall layout and placement of controls and instruments. Even here the 3D-models seem to have mediated greater focus on the physical presence on the bridge, compared to more of an "external observer" perspective being triggered by 2D. Many participants commented anecdotally that it was easier to picture themselves inside the 3D representations. In Table 4, the most frequent code overlaps (i.e. one coded comment bringing up a combination of several evaluation aspects) are shown, indicating further that the 2D perspective focuses the attention to overall layout, while 3D models alert participants to the effects of specific design details on line of sight and space (for movement).

Table 4. Most frequent code overlaps (indicating interrelated design aspects)

	2D	**Σ3D**
1	Overall layout - Line of sight	Display - Line of sight
2	Overall layout - Move something	Chairs - Space
3	Overall layout - Experience / anecdote	Overall layout - Space

From the semi-quantitative analysis, we find clear indications that the 2D and 3D models focus the evaluators' attention differently. The difference lies primarily in the perception of overall layout, line of sight and space when different models are used in evaluation.

3.2 Qualitative analysis: model comments

Based on the observation and comments from the participants, the main perceived advantages of the 2D model appeared to be that it was considered a familiar format, easy to read and interpret, and that it provides a good overview of the whole designed area. The main identified disadvantages were that only two dimensions could be evaluated at the same time (e.g. making it hard to judge heights of surfaces), and consequently that the flat representation can distort the perception of space in the workplace design.

The main advantages of 3D models perceived by the participants were that relative heights and depths were better conveyed in 3D, and that it was easier to perceive the relationship between the design and human dimensions (this was achieved using either an avatar or the participants themselves as a size reference to the models). One participant commented that one 3D model had completely changed their understanding of the detail design:

"Certain things I didn't even think about in the drawing, for example the window beams are much wider... I hadn't even reflected on that. (...) If you sit here, much [vision] disappears because of the screens..."

Disadvantages perceived by the participants were that 3D models would be harder to create and modify than a drawing. Here, participants mentioned time, space and competence as limiting factors for product developers and reasoned about the relative merits of different models, for example which type was easier to distribute:

"(...) this model [points to 1:16] can be sent, but you can't send a 1:1 model. On the other hand if you're going to the shipyard, it's good to be able to send a CAD omdel or even a 2D (..) so you can build your own perception of it first. Then maybe you'd have thought of some details even before you arrive and stuff. It'd give you more time to think".

Further, some participants commented that some types of 3D-models require more competence on the part of the evaluator, e.g. being able to navigate in a CAD-model.

"Some angles were good to see. But then, when you don't have control over [the CAD] (...) it can be difficult to (...) have it upside down."

4. Discussion and concluding remarks

The aim of this study was to compare 2D and 3D models as tools for evaluating workplaces. The results from the study clearly indicate that while both 2D and 3D models are effective elicitors of design feedback, the representations trigger different feedback foci during a user evaluation. In general terms, the 2D model triggers more of a "helicopter" perspective with the overall layout in focus, while the 3D triggers a more immersive focus, with emphasis on being on the bridge. The 2D representation enhanced an outside-looking-in view, while the 3D enhanced an inside-looking-out view with more attention to detail.

When transferring from 2D to a 3D model, the participants primarily re-evaluated issues regarding overall layout, line of sight and space. This is a strong indication that these factors are perceived differently in 2D and 3D models. While it may be easy to conclude that the 2D gave incorrect indications of design, it has not been possible to conclusively judge the relevance and accuracy of the user comments to confirm that. Further studies are needed to examine whether 2D gives an incorrect decision basis.

Furthermore, the results indicate that when participants in an evaluation are exposed to first 2D and then 3D models, the first model serves as a pre-emptive exercise for the participants to give feedback. The ensuing discussions in the group demonstrated that the primary aspects that are re-evaluated are related to line of sight and movement, which is probably influenced by the fact that a ship bridge environment was the object of evaluation and the scenarios involved information about the operative situation outside the ship bridge.

For practical use of models in workplace evaluations, it is important for product developers to select models with caution, since the model will affect the content of the comments. Both 2D and 3D models have advantages and disadvantages, which makes it hard to recommend the use of only one. Rather, a combination of a 2D drawing for the holistic overview, and one of the 3D models as a complement for easy assessment of movement space, field of vision, reach and accessibility is perceived to work best in practice. Furthermore, using any type of model can give product developers user insight into the success of their design intentions – both in the form of direct design feedback and more long-term learning about users in the form of anecdotes - but it should be remembered that different models will direct the evaluators' attention to different detail levels in the design. Choosing model representations mindfully may provide product developers with just the right information to pursue a user-centred design.

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Green exercise as a workplace intervention to reduce job stress. Results from a pilot study

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In a pilot study designed as a randomized controlled trial we investigated the impact of a green-exercise intervention on psychological and physiological indicators of stress in office-based employees. Fourteen employees volunteered in a two-week long intervention, during which they exercised either in a nature area or in an indoor setting. Compared with the indoor group the nature group reported higher environmental potential for restoration and positive affect, along with improved cortisol awakening response and marginally reduced diastolic blood pressure. Differences were not found for other constructs of affect (negative affect, fatigue and tranquillity), serum cortisol levels, and systolic blood pressure.

Keywords: Natural environment, workplace intervention, restorative environment, mental fatigue, job stress.

1. Introduction

Stress and mental fatigue are significant health threats to employees in office-based occupations. Long term over-exposure to stress can have deleterious effects, with increased risk of poor mental health, sleep disorders, cardiovascular diseases, cancer and premature aging (Juster et al., 2010). It is, therefore, important to protect employees' from the health threats of stress by implementing workplace interventions that can elicit restoration from stress and mental fatigue. Physical exercise is an effective stress-management strategy for employees (Bhui et al., 2012), and many employers promote access to exercise opportunities, e.g. through economical agreements with fitness centres or participation in sporting events.

Green-exercise is defined as any physical activity in contact with nature (Pretty et al., 2003), and it has been shown to provide greater benefits in terms of reduction of physiological stress (Li, 2010; Park et al., 2010) and restoration from mental fatigue (Aspinall, at al. 2013; Hartig et al., 2003) as compared to other forms of exercise. Experience of fascination and a sense of being away in natural environments are theorized to account for the restorative effects of nature (Kaplan, 1995). Therefore green-exercise intervention would be particularly appropriate as a stress-management strategy in the workplace.

The aim of the pilot study was to explore possible effects of green-exercise interventions in the workplace on psychological and physiological indicators of stress.

2. Materials and Methods

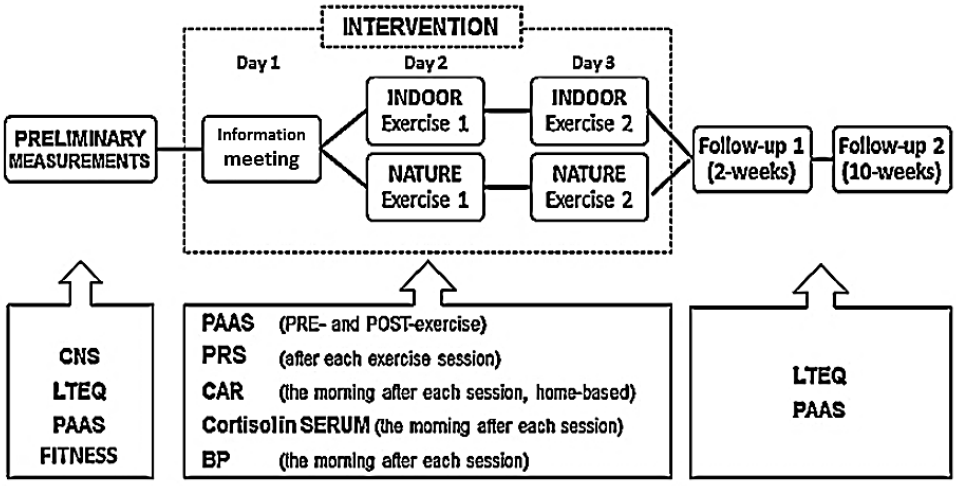
The study was designed as a between-subjects randomized controlled trial, including preliminary and follow-up measurements (Figure 1). Fourteen employees (7 females and 7 males, 49±8 yrs) volunteered in the study. The randomization was stratified by gender and age, ensuring that the two groups were fairly balanced for physical activity habits (Godin & Shephard, 985) and Connectedness to Nature (Mayer & Frantz, 2004). The intervention consisted of an information meeting and two exercise sessions, each including a biking bout and a circuit-strength sequence using elastic rubber bands (45-minutes, at about 55% of HR reserve, overall). The participants exercised either in a gym-hall (indoor group) or outdoors in a nature area nearby the workplace (nature group).

In order to instruct the participants on what intensity to keep during the biking bout, a Borg scale with descriptors in Norwegian (Borg, 1982; Hagströmer & Hassmén, 2009) was shown to them preliminary the exercise session: they were instructed to maintain a self-perceived moderately high intensity ("hard" in the caption, RPE= 15-16). Furthermore, to control that the workload intensity was equivalent for the two groups, during all the exercise sessions ratings of perceived exertion (RPE) were measured at completion of the biking and the strength bouts using the same Borg's scale, and heart rate (HR) was continuously measured using HR-monitor.

Perceived environmental potential for restoration was measured after each exercise session administering the subscales for Fascination and Being Away of the Perceived Restorativeness Scale (Hartig et al., 1997). Affect was measured at baseline and before and after each exercise session using the Physical Activity Affective Scale (Lox et al., 2000). Furthermore, affect was measured four- and 10-weeks after the intervention as a follow-up. Cortisol awakening response (CAR AUC_G and CAR AUC_I) and early morning cortisol levels in serum were measured as indicators of allostatic load (Juster et al., 2010) at baseline and the morning after each exercise session. Also blood pressure (BP) was measured at baseline and the morning after each exercise session between 8:00 and 9:00 AM.

For each study variable an estimate of the fixed effect 'group' (indoor vs. nature) controlling for baseline values was performed using Linear Mixed-Effects Modelling (SPSS, 2010).

Figure 1. Study design



CNS= Connectedness to Nature Scale; LTEQ= Leisure Time Exercise Questionnaire; PAAS= Physical Activity Affective Scale; PRS= Perceived Restorativeness Scale; CAR= Cortisol awakening response BP= Blood Pressure

3. Results

The findings of this study will be published in a special issue of the journal *WORK: A Journal of Prevention, Assessment & Rehabilitation* entitled "Workplace-based efforts in promoting health and preventing disability in Norway" (Calogiuri et al., in press). Therefore, in this paper, only a brief summary of the core findings will be reported.

No significant difference across groups was found for HR or RPE during exercise, indicating that the exercise sessions in the two environments were fairly equivalent in terms of workload. Compared with the indoor group, the nature group reported a greater environmental potential for restoration, with higher ratings of both Fascination and Being Away. When controlling for baseline values, the nature group showed greater improvements of positive affect as compared with the indoor group. Such higher ratings of positive affect were maintained throughout the follow-up, although some drop-outs occurred (n=11, overall). Reduced CAR AUC_I and marginally reduced diastolic BP were also observed in the nature group the morning after the exercise sessions. No difference was found at post-exercise for any of the other components of affective state, systolic BP, CAR AUC_G and cortisol levels measured in serum.

4. Discussion and Conclusions

This pilot study provides insights of methods and practice for future studies on health-impact of green-exercise interventions in the workplace. Furthermore, it also provides support for the idea that green-exercise interventions in the workplace can be a more valuable resource than 'traditional' indoor exercise in promoting health among employees, especially reducing psychological as well as physiological stress.

One of the strengths of the study is that we ensured controlled conditions, for example standardizing the time of day for the sessions and the measurements, limiting other exercise behaviours, and controlling the food intake in concomitance with the sessions and the measurements. Nevertheless some limitations in the design ought to be taken into account, especially the challenge of comparing such different exercise environments and the fact that we could not blind the study. Not least, due to a small-sample size, the generalizability of the results is restricted. Further studies on larger samples are needed in order to substantiate the results. We also recommend that further studies make use of measurements of mental fatigue and/or cognitive performance to better define long-term effects on work productivity and health.

Practical implications also ought to be taken into consideration. Overall, we received positive feedback from the participants, and most of them enjoyed exercising outdoors in nature. Nevertheless, the implementation of green-exercise interventions in the workplace might be challenging. Weather conditions and perceived safety are, for instance, important constraints on participation in green-exercise and many may prefer to exercise indoors as they perceive it more comfortable and safe. Personal feelings about nature and attitudes towards outdoor recreations might also determine whether or not one chose nature as an exercise arena (Calogiuri & Chroni, 2014). It is therefore important when implementing green-exercise interventions in workplaces to consider these challenges and plan a reasonable organization that includes information about the added benefits of exercising in natural environments.

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Development and validation of a workspace layout scale for use in green building certifications

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Green building certifications largely focus on resource reduction and environmental benefits. However, there is a growing interest in understanding how green buildings might also be efficient and effective places to live and work. In 2014 the Green Building Council of South Africa released its pilot Interiors Rating Tool that includes credits for the efficient using of building space. This study presents the development and validation (two administrations of the scale N=197 and N=257; 10 interviews; and a formal ergonomic workplace assessment) of a workspace layout scale to assess efficient space usage for building occupants. Good reliability and concurrent validity results suggest that the scale would add value both as a screening tool for formal ergonomic workplace assessments and as formal evidence for certification where these assessments are too expensive.

Keywords: green building, workspace layout, green ergonomics, sustainable work

1. Introduction

The US Environmental Protection Agency (2010) defines "green" buildings as the "practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's lifecycle". Within the context of green ergonomics (Thatcher, 2013), considerations of green buildings speaks specifically to the design of resource-efficient systems. Up until recently the focus in green building has been on the efficient use of environmental resources (i.e. land use, building materials, energy consumption, and water use), but within the last decade there has been an accelerated drive to also consider the health, wellbeing, and effectiveness of the building occupants. After all, buildings are built for people, they are the decision-makers determining which buildings get built, and they have to live and work in the structures that get built. Most of the work on occupant health, wellbeing and effectiveness in green buildings has focused on indoor environmental quality (IEQ) (Moschandreas & Nuanual, 2008; Paul & Taylor, 2008; Thatcher & Milner, 2012; 2014) such as improved airflow, temperature and lighting control, external views, the use of daylight, and toxin reduction; issues familiar to environmental ergonomics.

Achieving official recognition as a certified green building requires an 'objective' rating using one of the officially recognised rating tools such as Leadership in Energy and Environmental Design (LEED), British Establishment Environmental Assessment Method (BREEAM), or GreenStar. In addition to IEQ elements, Attaianese (2012) and Hedge and Dorsey (2013) have emphasised that green buildings also need good ergonomics if they are to support/create sustainable work systems. Ergonomics credits have now been included in the LEED Commercial Interiors rating system version 2.2 (Hedge & Dorsey, 2013) which can be obtained if it can be shown that the office environment has a comprehensive ergonomics process in place. However, the credit focuses primarily on the availability of ergonomics furniture and equipment and the provision of ergonomics training in their appropriate use. Attaianese (2012) emphasises that green buildings also need to consider the efficient use of space to optimise work functionality and serviceability. Duca (2014) noted that the ergonomics of green buildings in relation to issues of resource use is more extensive than furniture and equipment. A more efficient use of space also means that fewer natural resources are used to build, maintain, and

service that built environment (e.g. less space that needs to be environmentally controlled), but ergonomics emphasises that this should not be at the expense of efficient and effective work. Duca (2014) suggests that it is important to examine aspects such as how people move through the building, which areas are most frequently used, which areas face possible overcrowding, how do employees personalise space, and how do people find space that meets their work requirements. In 2014 the Green Building Council of South Africa (GBCSA) launched its new GreenStar SA Interiors Rating Tool. Not only does this tool encourage building design that focuses on good IEQ, but credits can also be obtained for an appropriate ergonomics fit-out, as well as for workspace design and efficiency. Formal, objective evidence, usually from a professional such as a certified ergonomist who has conducted a detailed workplace assessment, is usually required to obtain credits. However, for many organisations a formal workplace assessment would be prohibitively expensive (and extremely difficult since there are currently no certified professional ergonomists in the country) and so the GBCSA recommended a less expensive, alternative route of an occupant survey be developed. Since there is no generally available survey tool that looks specifically at issues of appropriate, workplace layout this study looks at the development and validation of a short survey tool to help the industry move towards designing and evaluating more effective workplace layouts.

2. Methods

The study design involved a number of stages. The first stage was the development of a suitable item-bank that would be appropriate for a range of different workplaces, from more traditional office environments (with specifically allocated desks) to more flexible workplace arrangements that included hot-desking and activity-based work. The second stage was to pilot-test the scale in an accounting and consulting organisation. This organisation moved from a conventional building to a green-certified building during the study period. This enabled us to evaluate two different types of workplaces but also to assess the sensitivity of the scale to physical changes in the working environment. In the conventional building most employees were allocated their own permanent workstation in a single-storey, open-plan office with many of the consultants operating on a hot-desking basis. In the green building, employees were spread across seven floors with a mixture of fixed workstations (for certain office-bound employees such as personal assistants and some senior managers), semi-permanent workstations (for work teams that shared functional tasks), hot-desks (for most of the consultants), and a wide range of meeting rooms (from private booths through to large meeting rooms). The GreenStar Interior Rating Tool had yet to be finalised during the building design stage but significant changes to the interior layout of the office space had been proposed to accommodate activity-based work (Sachs, 1995). At the time of the second administration, the workspace layout scale was also correlated with measures of physical and psychological wellbeing, perceived productivity, and job satisfaction. For the validation stage, follow-up interviews were conducted with building occupants in the green building and a formal ergonomics workplace assessment was carried out.

2.1. Scale development

The development of an item-bank for the pilot survey was initially sourced from existing post-occupancy building surveys (i.e. the BUS, the CBE, and the BOSSA). However, these instruments assess the workspace at a very general level (e.g. “does the office layout enhance or interfere with your ability to get the work done” (CBE, 4 items) and “do you have enough space at your desk” (BUS, 3 items)) and do not assess the workplace based on any ergonomics or human factors theory. To expand the item-bank based on ergonomics theory, ergonomics sources were identified including McCormick’s (1970) principles of Rational Workspace Layout (i.e. importance, frequency-of-use, functionality, and sequence-of-use), Oborne’s (1982) social requirements for a workplace (e.g. personal space, privacy, and collaborative space), and

other basic issues related to workstation layout (e.g. physical layout and personalisation). The initial version of the scale consisted of 9 items, which was increased to 13 items during initial pilot-testing with small sample groups. Responses were recorded on a 5-point Likert-type scale from "very dissatisfied" to "very satisfied".

2.2. Scale pilot-testing

The pilot-testing administrations took place: (1) in the conventional building three months before moving and (2) in a GreenStar-certified building twelve months after moving. The first administration (N=197) only consisted of the pilot workspace layout scale to check for item understandability and to establish a baseline measure of ergonomic workspace layout issues. At the point of the second administration (N=257) the revised workspace layout scale was administered together with measures of psychological wellbeing (Stewart-Brown et al., 2009), physical wellbeing (Hedge et al., 1996), and perceived productivity and job satisfaction (Thatcher & Milner, 2014). See Table 1 for a summary of the sample demographics. Before the move the average age of respondents was 37.41 years (SD=9.00) compared to after the move (34.47 years (SD=8.75).

Table 1. Demographic description of the two administrations of the scale.

	Before		**After**	
	N	**%**	**N**	**%**
Male	73	37	91	36
Female	124	63	167	64
Executives	39	20	25	10
Senior management	32	16	53	21
Middle management	64	32	57	22
Lower management	30	15	53	21
Administration	32	16	68	26
Permanent cubicle	142	72	53	20
Hot-desk	55	28	52	20
Semi-permanent desk	0	0	149	60

2.3. Scale validation

Follow-up interviews were conducted with ten employees who had moved into the green building. The interviews looked at how the building layout impacted on the work of the employees, and their perceptions, attitudes, and responses to the changes in the building. A formal ergonomic workplace assessment was also carried out on two of the seven floors of the building. Each of the floors was divided into three workspaces. This was to ensure that a holistic view of the building was gained with both the South side and North side being evaluated. The ergonomics workplace assessment involved two-hour observational shifts of the workplace that alternated between the three workspaces on each floor for two full working days and physical measurements of the workspace and workstations. The assessments incorporated the different workstation types as well as different meeting spaces and the other office facilities (e.g. storage, copying and printing, the rest-areas, bathroom facilities, etc.) in each designated workspace. The aim of the observations was not specifically to identify the ergonomic qualities of the equipment and furniture but primarily to see how employees made use of the workspace and to observe any ergonomic issues that occupants had with that workspace.

3. Results

3.1. Pilot-testing

The scale had good internal reliability both before ($\alpha = 0.82$) and after ($\alpha = 0.85$) the move with good item characteristics (kurtosis before the move: ± 0.06 to ±0.997, and after the move: ±

0.08 to ± 2.19; skewness before the move: ± 0.02 to ± 0.776, and after the move: ± 0.29 to ± 1.18) and few missing responses (15% before and 10% after).

3.2. Scale validation

The scale total only correlated significantly with job satisfaction (r = 0.26) and psychological wellbeing (r = 0.15) after the move where there were also important patterns of correlation with items on the scale and psychological wellbeing (between r = 0.01and r = 0.36), physical wellbeing (between r = 0.01 and r = 0.16), perceived productivity (between r = 0.01 and r = 0.16), and job satisfaction (between r = 0.08 and r = 0.25). A t-test comparing before and after measures demonstrated that the scale was statistically sensitive to significant improvements in 11 of the 13 questions as expected based on the workplace layout design changes in the new green building (see Table 2).

Table 2. Comparisons in the workplace layout scale items from before and after the move.

Item	Before	After
I can use the relevant furniture/appliances in the "work" area without physical space problems.	3.46	3.96*
My "work" area meets my work needs in terms of its physical layout.	3.51	3.77*
The technical equipment provided for my individual use meets my needs.	3.17	3.99*
The technical equipment provided for meetings and collective use meets my needs.	3.02	3.98*
Personal storage space is adequate.	3.46	3.30
My workspace enables me to interact with colleagues when necessary.	3.90	3.97
My workspace enables me to collaborate with colleagues (i.e. work on a project together) when necessary.	3.45	3.99*
The availability of collaborative meeting spaces is sufficient.	2.86	3.73*
My workspace enables me to meet with clients when necessary.	3.22	4.04*
My workspace gives me the space to work/operate without interruptions.	2.61	3.72*
My workspace allows private space when necessary.	2.45	3.41*
My workspace can be adapted to my individual preferences (i.e. within my "work" area).	2.87	3.30*
My workspace allows me to move throughout the "building' without being impeded by "work" area obstacles such as furniture and office equipment.	3.49	3.85*

* = statistically different at $p < 0.05$ comparing before and after administrations

The interview data provided corroborating evidence for problems and strengths identified in the pilot scale after the move. One respondent indicated that the green building workspace was "*the best workspace I have worked in … the layout is accessible, everything you need is there*". There were large numbers of positive comments in relation to improved technical equipment for work and meetings (e.g. "*I think the biggest win is the Wi-Fi and printers*" and "*the video conference rooms are brilliant compared to the old building*"), flexible meeting spaces (e.g. "*the meeting environments that we have on the ground floor and the first floor, seventh floor, and the work floors are fantastic*"), a work environment that facilitates collaboration (e.g. "*in terms of collaboration, It is like you do have more access to people*"), and access to private space when necessary (e.g. "t*here are quiet rooms for when you need to work in silence"*). Most negative comments were in relation to aspects that had not significantly improved – i.e. personal storage space and serendipitous interactions with colleagues when necessary (e.g. "*in the previous building you could quickly see a lot of people and whether they were there or not*" and "*now it becomes an irritation for me to get up from my desk and walk to my storage cabinet to fetch something, it is about the disruption*").

Corroborating evidence also emerged from the formal ergonomic workplace assessment. The biggest issue identified from the workplace assessment related to personal storage space. Only 63% of personal storage space was being used in the areas investigated and a large proportion of this space (25%) was being used to store office materials. This was one of

the aspects that did not significantly improve from before to after the move. Significant personalisation of the space was observable from the workplace assessment and this was an aspect that respondents felt favourable about in the scale responses. The formal ergonomic workplace evaluation did, however, identify that a number of walkways were blocked by filing cabinets and lockers which had been moved by the occupants. From the scale, respondents indicated that they could move through the building freely and presumably had adapted to these ad hoc modifications to their workspace.

4. Discussion

The initial pilot investigation shows the scale has promise, although it is possible that further refinements may be necessary to account for different office types. Further analysis with different building types is recommended. A scale such us this will help drive organisations to: (a) make it easier for organisations to evaluate the workspace layout of their interior workspaces; (b) consider ergonomic issues in the design of workspaces; (c) drive the efficient use of space for resource reduction; and (d) serves as an incentive for other green building certification tools to consider workspace aspects. The scale is not intended to replace a full ergonomic workplace assessment, but might be useful as an indicator tool that could initiate more in-depth analysis especially in work contexts where a full ergonomic workplace assessment is not economically feasible.

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Developing an environmental organisational climate concept, a few lessons from research on safety climate.

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There is great potential in organisations and corporations in terms of emission reductions, but there is also a human potential. In order to move towards greener organisations we might need to work on changing organisational climates and cultures. However, there is little work on (pro)environmental organisational climate (or sustainability climate). There are other specific climates that could be used as starting points, and perhaps the most closely related is safety climate. This concept is more than 30 years old (Zohar, 2014), and it is associated with safe behaviour and accidents at work (e.g., Christian et al., 2009; Kongsvik, Johnsen & Sklet, 2011).

1) There is often a trade-off between safety and profits (e.g, Madsen, 2013), with environmental issues this may be less pronounced, one example is energy efficiency. Although it can be problematic to focus on the economic aspects, this may be a starting point for many organisations.

2) Psychological ownership to work processes is an important antecedent to safe conduct at work, and safety climate (Zohar, 2014). This is likely to be similar for environmental climate.

3) One issue that seems relatively clear is that research on environmental climate should not get stuck in a search for dimensions, the factorial structure of safety climate is highly variable even for the same scale (see Zohar, 2014).

4) Management commitment to environmental issues must be perceived by the employees as being real, and not only as a formal policy in official documents (DuBois, Astrakhan, & DuBois, 2013). As illustrated in safety research, the slogan "safety first" can be the official policy, but employees may still believe that profits have a higher priority (Zohar, 2014).

5) Employees are discussing and making sense of events and priorities, this is relevant both in environmental and safety issues. Employees build a shared perception of safety climate (Zohar, 2014). In a similar way environmental climate can be built from the bottom up, for example starting with groups or individuals with specific knowledge and motivation (see Howard-Grenville, Bertels, & Lahneman, 2014).

It is also worth discussing whether we need a specific climate for sustainability or if this should be embedded in the corporate culture. The latter may be preferable, but difficult to achieve for many organisations today. We may need to identify barriers to change and conduct more research on change processes.

Transitioning towards an environmental organisational climate may be one way for organisations to avoid the "green washing"-label.

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A social sustainability perspective on an environmental intervention to reduce ship emissions

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This paper reports a case study examining the effects on the shipboard work environment of an operative decision to change fuel oil type on two Swedish passenger vessels operating in the Baltic Sea. The results show positive changes in work tasks, reduced exposure to harmful pollutants evaporating from the fuel, reduced use of chemicals for cleaning, and a generally cleaner work environment. The outcome illustrates the benefit of a systems perspective when evaluating environmental interventions. Here, the intervention can be seen as an investment that not only reduces emissions to the environment, but contributes towards sustainable working life at sea.

Keywords: work environment, ship emissions, fuel change

1. Introduction

The present paper reports a case study examining the effects on the shipboard work environment of an operative decision to change fuel oil type on two Swedish passenger vessels, operating routes in the Baltic Sea. While the decision to change fuel type was primarily made to meet the onset of more stringent environmental legislation to reduce harmful ship emissions, this study adopts a systems approach and investigates the intervention also from a work environment perspective. Specifically, the aim was to study how the change of fuel oil type have affected the work tasks performed by the engine crew on board and the working conditions in which they are performed, focusing on exposure to various physical, cognitive and chemical loads. Many of the work tasks involves handling of the fuel, and it is a common understanding from engineering personnel that it is easier and less dirty to handle distillate fuels rather than residual.

Ship emissions to air has been found to have a negative effect on public health; globally an estimated 60,000 deaths are attributed to air emissions from the shipping industry every year (Corbett et al., 2007). This is largely due to the release of sulphur dioxides (SO_x) and nitrogen oxides (NO_x) in dense populated coastal areas. Most ships still run on high sulphur residual fuels and about 70 per cent of all ships operate within 400 km from the coast (Endresen, Bakke, Sørgård, Berglen, & Holmvang, 2005).

In order to reduce harmful emissions, the International Maritime Organization (IMO) has appointed a number of emissions control areas where the emissions of SO_x and NO_x are under control (IMO, 2008). For example, since 1 January, 2015, the Baltic Sea is designated as a sulphur emission control area (SECA) where the sulphur mass in the fuel should not exceed 0.1 per cent. In order to comply with this new regulation, ship operators must reduce sulphur emissions either by using a low sulphur fuel (typically a more expensive distillate fuel) or by cleaning the exhaust gases. Either way, these requirements pose an operational as well as a financial challenge for ship operators. It is therefore important to have a solid knowledgebase before decision making, on both direct and indirect effects on operations.

For this particular study, the decision was already made to opt for a change to a fuel oil with lower sulphur content. In addition to the strictly technical issues, such as potential requirements for new equipment, logistical challenges for bunkering of new fuel, and so forth, there could be concerns about changes in work tasks, how they are executed and consumption of time and resources.

Another fuel quality may also result in differences in personal exposure to harmful and carcinogenic air pollutants. Previous research (*e.g.* Langer et al., 2014) has demonstrated that

the indoor air pollution on board is largely dominated by evaporative emissions from the vessel's own bunker fuel and emissions originating from the running of main and auxiliary engines and boilers.

It is fair to assume that changes related to the work environment will occur mainly in the engine room and affect the engine crew of marine engineers and engine ratings. The many tasks performed in the engine room on a vessel vary greatly in complexity and physical load. The increased development and implementation of complex automated technology for operation and control of machinery and equipment has brought with it new cognitive and mental demands on the operating crew. There are, however, still many physically demanding manual handling tasks that requires lifting, pushing, pulling and carrying of tools, materials or other objects. Strenuous manual handling involving awkward working postures or movements is a known risk for cumulative deterioration of the musculoskeletal system and acute trauma due to accidents (Kuiper et al., 1999). Despite substantial improvement of working conditions on board contemporary merchant vessels, the maritime industry still suffers from a high level of occupational accidents. Mortality and morbidity rates for seafarers remain among the highest for all occupations. Typically, accidents occur during daily routines (Hansen et al., 2006) and slips, trips and falls when walking from one place to another and in stairs or ladders on board are common causes of serious injuries (Jensen et al., 2005). In addition, daily working routines include exposure to various toxic and carcinogenic chemicals for e.g. cleaning purposes, treatment of fuel, boilers and cooling water systems.

2. Methods and material

The study employed a mixed methods approach, using different methods for collecting and analysing data. Field visits were made on board the vessels, before and after the fuel change. During these visits, interviews were held with engineers and engine crew and direct observations were made in order to bring out crew members' experiences and identify routines, tasks, tools and equipment related to the fuel system and significant for this study.

The Hierarchical Task Analysis (HTA) framework (Stanton, 2006) were used for analysis of the work tasks, aiming to identify various physical and chemical loads during normal operation and maintenance.

3. Results

The results of the study are structured here as initial teething problems followed by changes related to the work environment in terms of changes in operational routines and work tasks, and work environment and indoor air quality.

3.1. Initial teething problems

The new fuel did not mix well with the old fuel which led to initial teething problems and a lot of extra work for the crew cleaning fuel oil filters and purifiers (a device cleaning the oil from both water and solid dirt). For some time, the engine crew on one of the vessels had to clean the purifier every fourth hour.

The same vessel also had problems with the compressing springs in the fuel oil pumps. Several pump springs on different engines broke shortly after the fuel change, leading to downtime and extra work for replacement. However, since the replacement, there has been no further problems in this respect.

3.2. Operational routines and work tasks

Several operational routines have changed after the fuel change. Since all diesel generators run on the same fuel, there is no longer a need for a specific port generator. Indirect, this leads to a more even distribution of running hours and longer time between maintenance and engine overhauls. Furthermore, the interval for dumping and filling of lubrication oil has been

extended, and the interval between cleaning of the turbo chargers doubled.. The fuel and lubrication oil filters for the main and auxiliary engines are easier and faster to clean.

3.3. Work environment and indoor air quality

When a heavy fuel oil (HFO) is used, the bunker oil needs to be heated before it is combusted in the engine. The HFO needs to be heated to at least 100 °C to keep the viscosity low enough for pumpability. The low sulphur fuels are less dense and has usually a lower viscosity because it is generally less expensive to remove sulphur from a lighter oil blend (Stanislaus, Marafi, & Rana, 2010). The new fuels used by the two ships in this study are a lighter fraction of a heavy fuel oil, often called a hybrid fuel or an 'ECA oil'. Hence, fuel pipes and heat exchangers are not as warm when running on a distillate or hybrid fuel, and rather than 100 °C, the oil is heated to 60 °C – 70 °C depending on fuel quality, which results in less risk of heat exposure and burns.

Furthermore, the crew spends less time cleaning oil residuals as the new fuel is much easier to remove oil stains, and it is therefore less use of cleaning agents. Previously, several hours was spent each month removing clogged oil residues from the fuel pump´s drain pipes, which is a work task that is now almost eliminated on one of the ships.

A lower temperature of the fuel in the bunker tanks also means less toxic vapours in forms of lighter hydrocarbons.

4. Discussion of results

The results of the study show that some jobs have ceased entirely after the fuel change, while other work tasks are performed more seldom, demonstrating a potential for savings in both time and material resources in this respect. Furthermore, the change of fuel seems to contribute towards reduced exposure to harmful substances; both in terms of indoor air pollutants evaporating from the bunker fuel, and reduced use of hazardous chemicals for cleaning of fuel oil purifiers and filters.

The study is however limited in both range and by its clear Nordic and Baltic Sea focus. While it is beyond the scope of this study to calculate direct and indirect costs associated with the fuel change as such, the results show that the intervention comes with a silver lining, an added societal value in terms of improved employee health and safety at work. From an ergonomics perspective, the intervention can be seen as an investment that not only reduces emissions to the environment, but contributes towards sustainable working life at sea. The shipping industry is one of the most globalized industries in the world and the global merchant fleet is heterogeneous. Even if this particular case shows promise, what is good for the environment and the climate is not by proxy good for the work environment and employee health. Thus, decisions and measures need to be evaluated on a ship-to-ship basis and further research is needed on the impact of other solutions, for instance the use of LNG and methanol.

5. Concluding remarks

The outcome of this study illustrates the benefit of a systems perspective when evaluating an environmental intervention, taking into account not only economic and ecological effects, but also the impact on the working environment and job performance. While it is beyond the scope of this study to calculate direct and indirect costs associated with the fuel change as such, the results indicate that the intervention comes with a silver lining, an added societal value in terms of improved employee health and safety at work. From a work environment perspective, the intervention can be seen as an investment that not only reduces emissions to the environment, but contributes towards sustainable working life at sea.

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A METHOD FOR ASSESSING RISKS IN VISUAL ERGONOMICS

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Abstract

1 Introduction

A method for risk assessment in the field of visual ergonomics is under development. Insufficient visual ability can lead to increased workload and contribute to eyestrain and musculoskeletal discomfort. Although the relation between eyestrain and musculoskeletal discomfort is not fully understood, studies have shown that straining the eyes increases the musculoskeletal activity in the neck and shoulders (trapezius); associations between visually demanding work, eye problems, headaches and/or muscle problems have also been found (Aarås et al., 2001; IESNA, 2011; Zetterlund et al., 2009; Zetterberg et al., 2013; Toomingas et al., 2013; Richter et al., 2011; Richter et al., 2015). Problems due to insufficient visual ergonomics not only exist in computer intensive work, but in other professions as well, such as surgeons and postal workers (Hemphälä et al., 2011; Hemphälä et al., 2012).

The aim of this project is to develop a practical, easy-to-use, and time efficient risk assessment method for visual ergonomics. With this method, risk factors in the visual environment can be detected, and interventions implemented to reduce the prevalence of symptoms related to poor visual ergonomics among workers.

2 Methods

A first version of the risk assessment method has already been developed. In the spring of 2015, 27 ergonomists were taught visual ergonomics and introduced to the method. After the course, each ergonomist used the method to assess 8-10 workplaces, providing data and practical experiences from approximately 250 risk assessments. These data will be used to further develop and improve the method. During the fall of 2015 and spring of 2016, two other groups, each consisting of 30 ergonomists, will be trained in using the revised version of the risk assessment method in approximately 10 workplaces each. Data from these assessments will be used to test the validity and reliability of the method.

3 Results

The first version of the risk assessment method for visual ergonomics will be presented at NES 2015 together with the results from the approximately 250 risk assessments made by the first group of ergonomists. So far, the factors included in the method are objective measurements of illuminance, luminance contrast, illuminance uniformity values, size of work object, visual angle; expert assessment of the risk for glare; and subjective ratings of visual ability, eyestrain and musculoskeletal discomfort. Some tendencies have been found of correlations between an objectively-rated high risk for glare and eyestrain/headache, as well as between a high contrast glare/luminance ratio and eyestrain.

4 Conclusion

Several factors in the visual environment contribute to wellbeing and the level of performance. In this risk assessment method for visual ergonomics, ergonomists have been trained to evaluate, for example, the risk for glare, as one of the major risks. The risk assessment method presented will be discussed in relation to its usefulness in the prevention of discomfort and work-related disorders at workplaces.

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Spending too much time looking at digital screens? How to avoid visual problems!

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Abstract

In modern western societies, many people spend a considerable time each day viewing digital displays. This can include time viewing desktop or laptop computers at work, tablet devices while travelling to and from work, computer use at home, and viewing smartphones. In Norway, more than 70% of the population have access to a tablet computer, and more than 80% have access to a smart phone (Statistics Norway 2015). For many people screen-viewing time is likely to outweigh most other visual activities during waking hours.

Although some people can cope with the visual demands of display use, other people experience visual problems (Rosenfield 2011). These problems can include sore eyes, tired eyes, gritty eyes, problems focusing at a near distance, seeing clearly at a far distance after viewing a computer display and temporary periods of double vision. (Sheedy et al. 2003). It has been estimated that as many as 90% of computer users experience visual problems (Thomson 1998, Rosenfield 2011).

The development of new technology has progressed much more quickly than the publications of standards and guidelines containing advice for visual ergonomics and display use, and some current publications refer to obsolete technology such as CRT displays (Long et al. 2014). Generic guidelines are required to assist workplaces and individuals so that they can optimise visual ergonomics for all types of computer displays.

Purpose

The purpose of this oral presentation is to review the computer/visual ergonomics literature and apply this to modern computer usage. This presentation will provide tips and advice for computer users to help them achieve good performance and visual well-being, which can be applied to any type of visual display.

Methods

A literature review relating to visual ergonomics and computer use was conducted. Keywords such as computers, digital screens, displays, VDT, VDU, tablets, and smartphones were used in conjunction with keywords such as “computer vision syndrome”, asthenopia, eyestrain, visual fatigue, accommodation, convergence, near vision, glare and dry eye. Of special interest were studies which focussed on the limitations of the human visual

system and studies reporting evidence for improving visual efficacy and comfort while viewing digital displays at a near distance.

The principle recommendations were categorised into themes. These were mapped to the visual demands of four types of visual displays (desktop, laptop, tablet and smartphone computers) to develop general visual ergonomics recommendations for computer use.

Results

The main recommendations for computer use are as follows:

1) Limit the time viewing digital displays, take frequent rest breaks and remember to blink your eyes
2) Have your vision examined. A general- or special purpose correction might be helpful.
3) Optimize the screen-viewing situation.
    a. Ensure a good general ergonomic work position.
    b. Optimise the visual display settings and ensure characters on the display are easy to see.
    c. Avoid glare, too high contrast in the surroundings, and reflections on the display.
    d. For most people and situations, a downward angle of gaze is preferred. The primary display should be located to allow a straight ahead viewing posture.
    e. Optimize the indoor work environment parameters such as relative humidity.

Conclusion

Visual ergonomics recommendations for visual display use can be applied to a range of screen-based visual interfaces. By following relatively simple generic guidelines for visual display technologies, people can function better, be more productive and have improved visual comfort.

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Prismatic glasses reduces neck pain in dental personnel

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Keywords: Neck pain, intervention, dental personnel

Background:

Symptoms and diseases from muscles and joints are frequent in the general population and thus constitute a major public health problem (Kinge et al, 2015). A large proportion of these symptoms/disorders could be referred to as work related (Alavinia et al, 2007). Physical risk factors at work are frequently present in dentistry, particularly during work in the oral cavity (Åkesson et al, 2012). Since 2007, prismatic glasses are available on the market. These glasses are constructed like bifocal glasses, where the lower part of the glass is replaced by prisms that bend the light path downwards; for the current glasses by 5 °. A randomized controlled study of 45 dentists/dental hygienists in municipal dental care units in Region Västra Götaland, showed that the prismatic glasses significantly reduced the exposure to extreme forward bending of the head / neck at work (Lindegård et al, 2012). Hence, the main aim of this study was to investigate the effects on self-reported neck/shoulder pain, clinically diagnosed conditions and perceived exertion in neck/shoulders after a large scale intervention with prismatic glasses.

Methods:

The study population consisted of dentists (n=355), dental hygienists (n=173) and orthodontic assistants (n=36) from 78 out of 110 dental care units in the region Västra Götaland. Through self-selection one intervention group (n=371) and one reference group (n=193) was formed. All participants were assessed at base-line and at follow up (12 month after the intervention) by means of questionnaires (background data, neck-complain frequency and perceived exertion at work), clinical examinations according to the HECO-protocol (musculoskeletal pain, clinical diagnoses in the neck and self-rated work ability).This study was conducted as a "natural" intervention following the implementation of prismatic glasses in the dental care organizations in the Region Västra Götaland. This is the reason for self-selection into the intervention group.

Results:

The intervention group reported, higher prevalence of neck/shoulder pain (56%, n=129) as well as a higher prevalence of clinical diagnoses in the neck/shoulder area (17%, n=39) at baseline, compared to the reference group (40%, n=36 and 7%, n=6). Moreover, individuals who received prismatic glasses improved significantly more concerning musculoskeletal pain (p=0.047), diagnoses in the neck (p=0.025), perceived exertion during work (p=0.002) and reported work ability (p=0.040), compared to the reference group 12 month after the intervention.

Conclusions:

The practical implication from these results are that recommendations regarding dental ergonomics should include the use of prismatic glasses both as primary and secondary prevention of work related neck pain in dental personal. Such glasses should also be tested in other situations where workers, due to sight demands, work with long term neck flexion, such as assembly work.

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Effect of three-dimensional central visual stimuli on vergence control

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Keywords: Binocular vision; stereoscopic vision; three-dimensional drive; two-dimensional object; vergence control; computer work.

ABSTRACT

Background: In general we spend more and more time doing computer work, i.e., we spend more and more time in a two-dimensional (2D) visual environment which provides a reduced number of cues for vergence control. It is therefore reasonable to believe that the reduced accuracy of the vergence and accommodative control systems due to the absence of three-dimensional (3D) features could be one of the attributing factors to the so called computer vision syndrome (CVS).

Objective: Since an interaction between binocular disparity and the vergence system takes place in order to reduce retinal disparity it is likely that vergence control, as measured with the near point of convergence (NPC), will be better if the target used for measurement has 3D

features in its most central parts. The aim of the present study was therefore to investigate if the NPC would give a better result using a fixation target with centrally placed 3D features compared to a 2D target.

Methods: Twenty three subjects (2 men, 21 women; average age 30.0 years ±7.36 SD) with normal binocular vision, but who experienced diplopia when a fixation target was brought close to the eyes, had their break point NPC measured using a modified RAF-ruler. A metal cube and a printed image of the cube were used as a 3D and 2D stimulus. The measurements were repeated three times in each subject for each test condition, in total 6 randomized NPC measurements.

Results: On average a significant difference in NPC ($p = 0.0172$) was found for break point NPC with a 3D stimuli (mean: 7.27 cm ± 2.37 SD) giving the better result as compared with a 2D stimuli (mean: 8.02 cm ± 2.82 SD). A low, but statistically significant ($p=0.0074$), correlation ($R2 =0.2953$) was found between the individual improvement in NPC from 2D to 3D stimuli vs. the average 2D NPC. Comparing the most remote recorded NPC values of the three repeated measurements under each stimulus condition a significant difference was found ($p =0.0159$, $t=2.612$) with 3D stimuli giving the better result.

Conclusion: The results of this study demonstrate the influence of binocular disparity stimuli on the vergence control as NPC was showed to be better if the target used for measurement had 3D features in its most central parts. In other words, 3D stimuli act as fusional guidance for fixations which means that fixation accuracy and stability increase. From a clinical point of view this would be interesting since it could explain why a large proportion of subjects report vergence related symptom in relation to activities mainly involving 2D stimuli in the central part of the visual field (e.g., computer work, tablets and smart phones).

INTRODUCTION

When an object is moving closer towards the eyes retinal disparity is consistently introduced and the vergence response is then believed to be mainly driven by the disparity vergence component together with accommodative vergence and proximal vergence interactions (Cormack et al., 1989; Erkelens & Regan, 1986). Vergence eye movement is mainly driven by retinal disparity. Retinal disparity within Panum´s fusional area is binocular vision in which the two retinal images of a single object do not fall on corresponding retinal points, that is, when the object lies off the horopter. Different test targets have historically been used to measure NPC including an accommodative target, a penlight, a bell, a black vertical line on a white card, and a penlight with red and green glasses (Ciuffreda, 1974; Scheiman et al., 2003, 2005a, b; Adler et al., 2007).

The target most commonly used for measurements of NPC is a vertical line with a central fixation dot printed in black on a white card (as on the RAF-ruler). In such a setting the central portion of the target is perceived as two-dimensional (2D) whereas the box in which the card is fitted (i.e., with the RAF-ruler) is three-dimensional (3D). With this arrangement binocular disparity within Panum´s fusional area is eliminated from the central visual field something which is not of importance as long as fine binocular disparity is not part of the vergence control mechanism.

Scheiman et al. (2003) found that recorded NPC values with penlight and penlight with red and green glasses were more receded compared to NPC values measured with an accommodative target or penlight alone. Furthermore, their results showed that the accommodative target appears to provide the best precision. However, their result suggest that to best detect the symptomatic convergence insufficiency (CI) subjects, the penlight with red and green glasses is the most accurate target to use measuring break point of convergence and

NPC recovery. However, to our knowledge, no study has evaluated the effect of binocular disparity while measuring NPC.

Binocular disparity within Panum´s fusional area is the slightly different view of an object due to the horizontal separation of the two eyes. When fixating a 3D object without any retinal disparity (i.e., the two visual lines from the foveas, which are corresponding points, meet exactly on the same part of the object) all other parts of the object will not project to corresponding retinal locations. Due to neural coding of binocular disparity in the two eye´s 2D images we are able to perceive the world in 3D (Qian, 1997). This neural coding takes place at several cortical areas such as V1, V2, V3, V3A, VP (ventral posterior), MT (middle temporal – V5) and MST (medial superior temporal) and SC (superior colicullus) (Gonzales & Perez, 1998). Cumming & Parker (1997) and Howard & Rogers (1995) have further shown that binocular disparity within Panum´s fusional area is a signal, not only to compute stereoscopic depth, but also to provide information to the vergence system for fine eye alignment. This interaction of binocular disparity visual input and the vergence system takes place in order to help the vergence system, not only reduce retinal disparity, i.e., reduce fixation disparity within Panum´s fusional area to a minimum, but also to bring both eyes in register in order to optimize stereoscopic perception. It is therefore likely that vergence control, as measured with NPC, will show to be better if the target used for measurement has 3D features in its most central parts and not only in the periphery as is the case with the target most commonly used today. The aim of the present study was therefore to investigate if the NPC would improve when a fixation target with centrally placed 3D features (i.e., increased binocular disparity stimulation) was used as compared with a target with only centrally placed 2D features. From a clinical point of view this would be interesting since it could explain why a large proportion of subjects report vergence related symptom in relation to activities mainly

involving 2D stimuli in the central part of the visual field (e.g., computer work, tablets and smart phones).

MATERIALS AND METHODS

The NPC measurements were assessed in 23 subjects (2 men, 21 women; average age 30.0 years ±7.36 SD) with asymptomatic (determined through history and symptoms) binocular vision but who experienced diplopia when a fixation target was brought closer than 16 cm to the eyes using the RAF-ruler (i.e., defined as reduced but not defective by the RAF-ruler). Subjects were recruited by consecutively asking students and staff at the university campus, Karolinska Institutet. All the subjects were asymptomatic, were found to be free of ocular pathology and strabismus, had no history of ocular treatment, took no medication with known effect on visual acuity and/or binocular vision, achieved at least 6/6 Snellen visual acuity both monocularly and binocularly, and had stereo acuity with the TNO (random-dot) stereo test of 60 sec or better. Cases with disorder of accommodation and vergence were excluded, but cases with refractive errors and heterophoria were included as long as the heterophoria did not give rise to any symptoms. None of the subjects were informed about the possible effect of different targets on NPC measurements. Ethical approval was granted by the Regional Ethical Review Board in Stockholm and informed consent was obtained from all subjects. The study adhered to the tenets of the Helsinki declaration.

Procedure

The measurement of NPC was performed using a modified RAF-ruler. The stimulus for the 3D condition was a 1.5×1.5 cm matte colored metal cube with colored flags (see *Figure 1*). The frames and details of the flags were elevated 0.5 mm from the surface of the cube in order to provide 3D features in all parts of the central visual field. A single star in the European Union flag (see arrow in *Figure 1*) was used for fixation. The part of the visual field covered by the cube increased as the cube was brought closer to the eyes (see *Table 1*). The 2D object

was a color printed image of 3D object (see *Figure 2*). Subjects were instructed to fixate the same star (1 mm in diameter) for both the 3D and 2D paradigms.

Figure 1. Illustration of the 3D object (1.5×1.5 cm), matte colored metal cube with colored flags. The white arrow points at the star used for fixation.

Table 1. Field size, in degrees, of the visual field covered by the cube at different distances.

Distance (cm)	**10**	**20**	**30**	**40**	**50**
Field size (degrees)	8.53 x 8.53	4.30 x 4.30	2.86 x 2.86	2.15 x 2.15	1.72 x 1.72

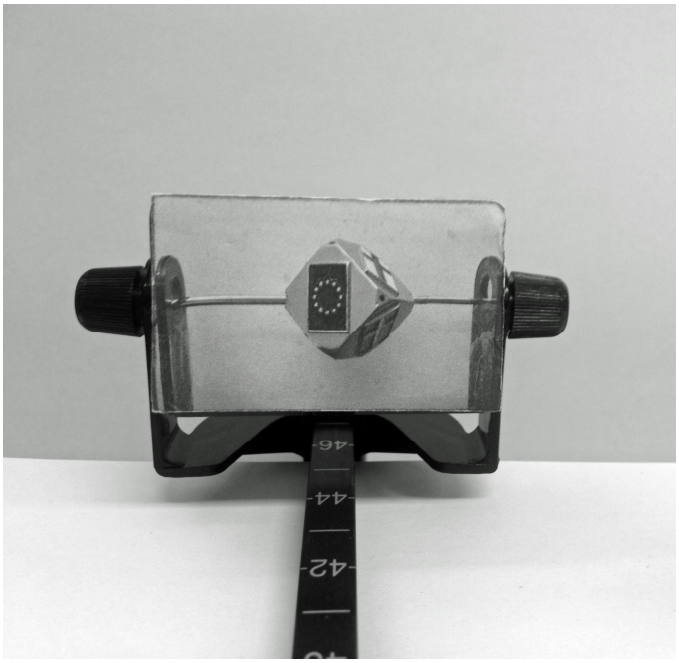

Figure 2. Illustration of the 2D object, a color printed image of the 3D object.

As the target was moved closer along the midline, subjects were instructed to keep the star single as long as possible and to report as soon as they perceived the star as double, i.e., break point NPC. At the same time they were instructed to ignore any blurring of the object. The RAF-ruler was supported against the subject's face with a downward inclination of 15 (±5) degrees in relative to visual angle (London, 1991) during the assessment process. Initially the target was placed at 50 cm from the subject's eyes and then slowly moved closer by a speed of about 5 cm/sec (London, 1991). The distance at which the subject reported double vision of the star was noted. The 3D cube had the fixation star at the same position as original RAF-ruler's fixation target so that the notation given by the RAF-ruler was correct. However, for the 2D target, which was superimposed on the original target the notation was reduced with 0.35 cm since the object was placed closer (see *Figure 3*). The measurements were repeated three times in each subject for each test condition (i.e., in total six NPC measurements) and the average and most remote measurements for the two conditions of each subject were used for analysis. The order of the 3D and 2D NPC measurements was randomized, i.e. test started

with 2D and 3D alternately when changing test subject. The surrounding area had an illuminance level of 550 lux with a target luminance of 53 cd/m^2 (gloss value 2.0) for the printed image and 75 cd/m^2 (gloss value 15.0) for the 3D object.

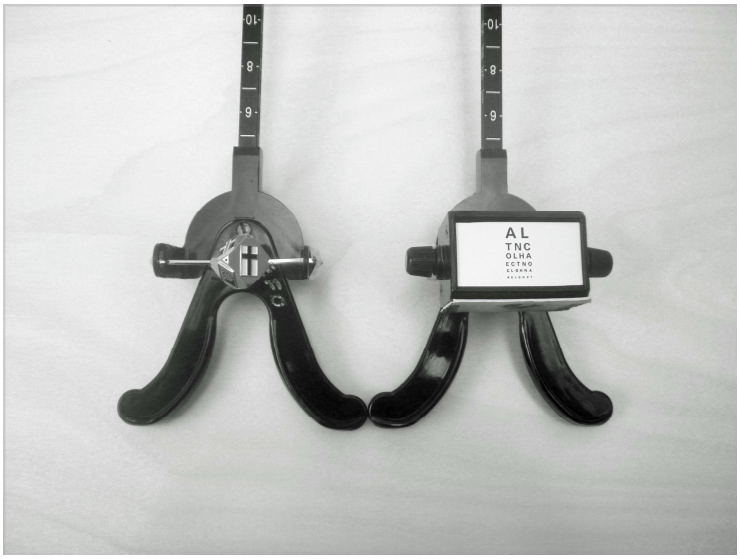

Figure 3. Illustration of the 3D and 2D objects end point of the RAF-ruler.

Statistical Analysis

Statistical analysis was done using the statistical software (INSTAT; Graph-Pad Software Inc., San Diego, CA, USA). A paired two-tailed t-test and correlation assessment was used for analysis of the data.

RESULTS

The results are based on the average (mean) of the three repeated measurements of break point NPC with the 3D and 2D stimuli in each subject (N=23), and for the most remote NPC measurement under the two testing conditions. A graph of measured individual results for each subject is shown in *Figure 4*.

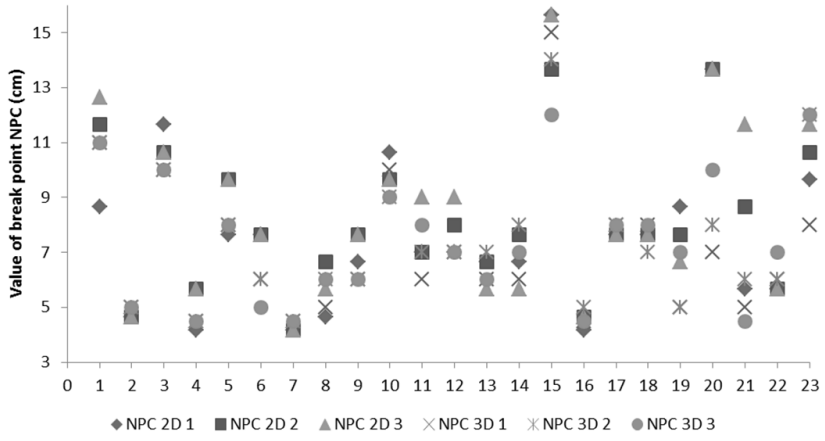

Figure 4. All measured individual results of break point NPC for each subject. NPC 2D 1-3 = first, second and third measurement of NPC with the 2D object, NPC 3D 1-3 = first, second and third measurement of NPC with the 3D object.

The statistical analysis of the average break point NPC showed that there was a significant improvement in NPC ($p = 0.0172$, $t = 2.577$) under the 3D condition (mean: 7.27 cm ±2.37 SD) compared with the 2D condition (mean: 8.02 cm ±2.82 SD).

A low, but statistically significant ($p=0.0074$), correlation ($R^2 =0.2953$) was found when analyzing the individual improvement in NPC from the 2D to the 3D condition versus the average 2D NPC (see *Figure 5*).

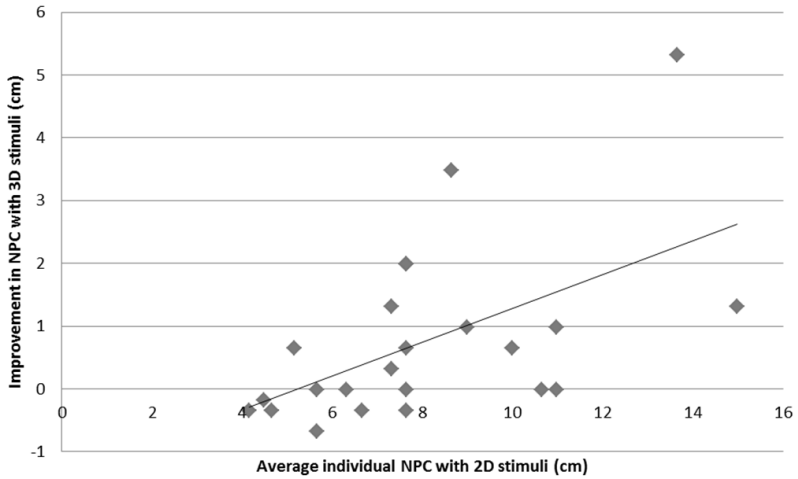

Figure 5. Illustration of the correlation of individual improvement in NPC from the 2D to the 3D condition versus the average 2D NPC.

Comparing the most remote recorded NPC values of the three repeated measurements under each stimulus condition a significant difference was found with 3D stimuli giving the better result ($p = 0.0159$, $t = 2.612$).

DISCUSSION

This experiment demonstrated that 3D features in the most central part of the visual field provide a significantly better average value, and less remote value of the repeated measurements of break point NPC measurements. The results therefore demonstrate that vergence control is reduced when the central part of the target only contains 2D features as compared with when it contains 3D features. In other words, 3D stimuli acts as fusional guidance for fixations which means that fixation accuracy and stability increase. In light of this one would expect that those with the most remote NPC under 2D conditions have a less remote NPC under 3D conditions. Although such a correlation could be demonstrated, it was fairly weak. A fatigue could be seen in recorded values comparing last recorded value of the three measured with the average individual value using both stimulus (2D: 10 subjects; 3D: 7 subjects), though, using the 3D stimuli the last recorded value was also better than the average recorded individual value in 6 subjects.

Our results are also in line with the results of Blythe et al. (2012) who found that the presence or absence of different depth cues systematically affected the characteristics of human binocular coordination. Their data indicated depth-appropriated vergence response to real 3D stimuli, but a lack of appropriated vergence response to parafoveal disparity cues for stereoscopic images.

Due to the cross-link between vergence and accommodation improved vergence control would also improve accommodative control. This explains the results of Rosenfield & Gilmartin (1990) who found that accommodation was more precise under closed-loop vergence conditions as compared to open-loop vergences while fixating a 3D target.

Furthermore, Ciuffreda (1974) showed in his study that NPC measured using target with high accommodative demand result in better NPC measurements. He found less variability in the NPC when measured with an accommodative target compared to a penlight as a target. When we clinically test for vergence capability using NPC as a measure the patient use all components of convergence response including fusional convergence, proximal convergence, and accommodative convergence. Therefore, using an accommodative target maximizes the accommodative demand and accommodative convergence, the NPC should, theoretically, be maximized with this type of target (Scheiman et al., 2003).

Moreover, our clinical experience is that subjects with convergence insufficiency (CI) reports greater problems in association with doing activities in which the central part of the visual field consist of mainly 2D features (e.g., reading books or doing computer work) as compared to when 3D features are present (e.g., building LEGO). We think that this clinical observation is in line with the results of this study since vergence control was found to be strengthened when 3D features are present in the central visual field.

The visual environment is conducted to two-dimensional stimuli with an increasing amount of time spent reading electronic documents on computer screens, tablet and mobile phones, i.e. reading on a regular basis. Therefore, it is reasonable to believe that presence of a two-dimensional visual environment when performing, e.g., computer work contributes to related visual symptoms, i.e. computer vision syndrome (CVS). Additionally, since the stimuli supporting the vergence control are limited and the fact that we are working long periods with different types of screens the vergence control is negatively affected and symptoms arise.

CONCLUSION

The results of this study demonstrate that vergence control, during measurements of near point of convergence, is negatively affected when the fixation target lacks centrally placed three-dimensional features. Since we spend more and more time in a 2D visual environment,

e.g., doing computer work, which provides a reduced number of cues for vergence control, it is reasonable to believe that the reduced accuracy of the vergence and accommodative control systems due to the absence of 3D features could be one of the attributing factors to the so called computer vision syndrome (CVS).

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Development of occupational health practice guidelines: a Swedish model

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The present study describes the development process of the first clinical practice guidelines on low back pain, the content and how they were launched to be used by occupational health service in Sweden. The method is applied to the ongoing development of clinical practice guidelines for 1) Health screenings at the worksite, 2) Prevention and management of common mental disorders, and for 3) prevention and short treatment of harmful alcohol consumption. Experience of participation by clinicians and researchers was overall positive. However, group-members indicated that expectations and prerequisites should be more clearly presented when working with clinical practice guidelines.

Keywords: Occupational health service, evidence-based-practice, clinical practice guidelines, community of practice group, low back pain

1. Introduction

There is to date a great interest and need for implementing evidence-based practices within the occupational health services in Sweden (Björk Brämberg et al. 2015) as well as in other countries (Hulshof et al. 1999, Kinnunen-Amoroso 2013). This is not only apparent among the occupational health professionals, but also among employers of customer companies, as they are responsible for financing the occupational health service. Moreover, according to the Swedish work environment act, employers are obligated to have some kind of access to occupational health service.

In order the facilitate evidence-based practices in the occupational health service, the Unit of Intervention and Implementation Research at Karolinska Institutet together with the Swedish Occupational Health Association initiated the development of occupational health clinical practice guidelines (CPGs). The guidelines are developed by a multidisciplinary community of practice groups, consisting of consultants from occupational health services, researchers and representatives from the Swedish Occupational Health Association. The first guideline that was presented was the clinical practice guideline (CPG) for low back pain, since low back pain is a major cause of work disability (Beaven et al. 2009). Due to the high prevalence of low back pain among workers it is also one of the most commonly encountered problems within the occupational health service (Walsh et al. 2008). The occupational health services have a unique role in the management of non-specific low back pain, as they have the possibility to assess and

intervene on multiple risk factors, including those related to work, this in contrast to for example the primary health care. Several guidelines for low back pain have previously been published. However, few of these have a clear focus on interventions at the workplace. Research suggests that the management of low back pain in occupational health service should be in accordance with the recommendations of evidence based guidelines (Staal et al.2003). As the mere existence of guidelines is not a guarantee for their usage there is a great need for effective implementation strategies to increase the use of CPGs (Francke et al. 2008).

2. Objectives

The present study describes the development process of the first CPG on low back pain, the content and how they were launched. Currently, the method is applied to the ongoing development of CPGs for 1) Health screenings at the worksite, for 2) Prevention and management of common mental disorders, and for 3) prevention and short treatment of harmful alcohol consumption. These guidelines will also be presented.

3. Methods

The development process of the guideline for low back pain started in 2012 by forming a multidisciplinary community of practice group. The concept has previously been described in the literature (Li et al 2009). The group met regularly three times per semester, during a period of a year and a half. Between the meetings, the members had assignments to progress in the development of the CPG. During the meeting experts in the field gave presentations on topics, such as implementation, evidence based practice, assessment methods, evidence-based interventions and more. At the first meeting, all participants were asked to write down their expectations, on the up-coming work with the guideline.

The literature search for evidence to answer the stated questions was conducted by the researchers within the group in consultation with an external advisory group. It was also guided by discussions held within the group and practical experiences. The starting point of the search was a Swedish governmental report, which provides recommendations for interventions aimed at non-specific low back pain (SOU 2011). The recommendations in the report are based on existing guidelines as presented in our results. The guidelines and reviews in the report are mostly aimed at managing non-specific low back pain within the primary care setting. Complimentary searchers were therefore conducted for relevant articles related to diagnosis, assessment and intervention for non-specific low back pain within a worksite/occupational health setting. A systematic search was conducted through PubMed, the Cochrane Database of Systematic Reviews (1966 through 2013), reference lists and grey-literature.

Based on the presentations performed by the experts, literature in the field, group-work and discussions the practice guidelines were developed following the recommendations of existing handbooks on guideline development. To evaluate the development process the group completed a questionnaire on demographics and expectations of participation in a community of practice group and observational data were collected.

4. Results

The community of practice group consisted of 13 occupational health multiprofessionals (10 women); physician, nurse, physiotherapist/ergonomist, psychologist, engineer, and health promotion specialist, three researchers from Karolinska Institutet and two representatives from Swedish Occupational Health Association. In total the group described 19 different expectations for participation. Most of the expectations related to evidence-based methods; to gain knowledge about evidence-based methods and how to implement these methods into practice. The evaluation of the development process of the guideline for low back pain showed that group-members indicated that expectations and prerequisites should be more clearly presented when working with clinical practice guidelines. This way they may receive more support from their employee to actively participate in the multidisciplinary community of practice group. This was therefore adjusted in the development process of the other guidelines. The

recommendations given in the CPG are based on existing international guidelines e.g. European guidelines for the management of chronic nonspecific low back pain (Van Tulder et al. 2006); Alberta Clinical Practice Guidelines Program (2009); diagnostic therapeutic flow-charts for low back pain patients: the Italian clinical guidelines (Negrini S et al. 2006); New Zealand Guideline Group (2004); the Institute for Clinical Systems Improvements (ICIS 2008); clinical practice guideline from the American College of Physicians and the American Pain Society (Chou et al. 2007); National Institute for Health and Clinical Excellence (2009)) and systematic reviews such as (Holm, 2010; Koes et al., 2010; Dagenais et al., 2010). It was also based on reviews focusing on occupational health service practice and methods for assessing exposure at the workplace (Takala et al. 2010) as well as effective interventions at the worksite (Tompa et al. 2013).

The CPG on low back pain contains six sections: introduction, flow-chart assessment, intervention, implementation and appendices. Useful knowledge on implementation theory and guideline development is referred to in the guideline (Shekelle et al. 2012, Gagliardi, Brouwers 2012). Throughout the guideline a participatory approach is emphasized to actively involve the employer, the employee and the professionals from occupational health service who are providing the interventions. The CPG for low back pain were launched at a national seminary in January 2014 and after that free available at the internet (Företagshälsans Riktlinjegrupp 2013).

Currently, three more CPGs to support the use of evidence-based methods within the occupational health service are being developed. The development of the CPG for Health screenings at the workplace, and of the management of common mental disorders started September 2014 and will be completed and published September 2015 (Företagshälsans Riktlinjegrupp 2015). These CPGs will be presented with the same structure of content as mentioned above.

The guideline for health screening and intervention is amongst others based on research focusing on the effectiveness of health assessments at the workplace, which are combined with interventions (Grooten et al 2014) and studies with a specific focus on the role of the occupational health services in promoting healthy behavior. (Kwak et al 2014). The guideline for common mental disorders is based amongst others on results from a review by Bergström et al. (2015) and relevant guidelines (Hulshof 2015, Joosen et al. 2005) and reviews such as (Martin 2009, Nieuwenhuijsen et al. 2010, Routsalainen et al. 2014).The work with CPG for prevention and short treatment of harmful alcohol consumption started Mars 2015 and will be completed during fall 2015. Webb et al. (2009) have published an interesting review of work-place interventions for alcohol-related problems. This is one among several references that has formed a basis for the work developing this specific guideline.

5. Conclusions

There is a great need to facilitate the translation of research into practice within different countries. The approach of using a multidisciplinary community of practice approach has shown to be useful for developing clinical guidelines for low back pain, health screenings at the workplace and the guideline for common mental disorders. Participants in the multidisciplinary community of practice group exchanged experiences and scientific knowledge as well as using existing international guidelines in order to develop the guideline.

A big focuses of the occupational health practice guidelines is a participatory approach, with an early involvement of the employer in among others the assessment of the workplace, adjustments in the workplace and tasks of the employee in order to support employees. Working with clinical practice guidelines is a starting point to facilitate the implementation of evidence-based practices in occupational health service daily routines. Further studies are needed to follow the implementation process of the clinical practice guidelines. At the conference, results from the development process of working with clinical practice guidelines for health screenings at the worksite, for management of common mental disorders, and also for prevention and short treatment of harmful alcohol consumption will be presented.

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New legislation in Sweden regarding the organizational and social work environment

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The Swedish Work Environment Authority, SWEA, will issue new provisions regarding the organizational and social work environment. The new legislation will be unique, no other country has provisions of the same kind. Sweden has had general advice on psychological and social aspects of the work environment since 1980 (AFS 1980:14). 2004 a draft for provisions was abolished due to, among other things, strong resistance, particularly from the employers' organizations. This time, the proposal has come so far that it is ready to be decided in September. The provisions will come into force in March 2016.

Keywords: Submission guidelines, Paper layout, References, Deadline

Aim

The aim of the provisions is to establish pre-requisites for a good work environment considering organizational, psychological and social factors.

Content of the Provisions

The provisions apply to all businesses in which employees perform work for employers. Pupils, students and inmates are excluded. Organizational work environment is defined as conditions and prerequisites for the work which include management and governance, communication, participation, job decision latitude, distribution of work tasks, work demands, resources and responsibilities.
Social work environment is defined as conditions and prerequisites which include social interaction, cooperation and social support from managers and colleagues.

The demands that have attracted the most attention and debate concern the obligation for the employer to

- set up goals for the organizational and social work environment,
- make sure that the work tasks and the powers assigned to the employees do not cause an unhealthy workload, and
- take measures to prevent that the organization of the working time leads to ill health among the employees.

The provisions also contain requirements on the employer to prevent victimization at work and counteract insults and harassments. The existing provisions on victimization at work (AFS 1993:17) will be repealed when the new provisions come into force in March 2016.

Opposite views among the social partners

During the fall 2014 the proposal on the provisions was sent out to the social partners and other organizations for external consultation. There was no consensus between trade unions and employer organizations regarding the demands concerning goals for the

organizational and social work environment, unhealthy workload, and organization of the working time. The views were opposite and polarized. Although the proposal was reviewed on the basis of the comments and the text has been revised, it is still a watershed. The employer organizations consider them to intervene with the employer's right to control how the work is organized and managed. The trade unions are in favor of the provisions and would like some of the requirements to be even more far-reaching.

Communicating the new Provisions

The Swedish Work Environment Authority has initiated a communication project that aims to spread information and knowledge about the new provisions to various stakeholders including the social partners. Training of inspectors, experts and administrative officers at SWEA about the provisions and implementation of the requirements is an important part of the project.

User involvement – a way to successful implementation of new methods

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The Danish Working Environment Authority (DWEA) has started a project to find better ways to prevent musculoskeletal disorder (MSD). Involving enterprises is an important part of the project to ensure good results when new initiatives are implemented.

Keywords: User involvement, musculoskeletal disorder, prevention, inspection methods and instruments.

1. Introduction

The Danish Working Environment Authority (DWEA) has started a project to find better ways to prevent musculoskeletal disorder (MSD). Involving enterprises is an important part of the project to ensure good results when new initiatives are implemented.

The background to the project is an ambitious working environment strategy towards 2020 which the Danish government has agreed on. The goals include a 20 % reduction in overload due to musculoskeletal strain. A status from 2014 shows that overloads already are reduced by about 12 %. Even though we are well on the way to reach the aim DWEA wish to continue the focus on MSD and adjust the efforts to achieve an even better prevention of MSD.

2. Methods

DWEA believes that enterprises can reach a higher level of prevention if DWEA change the inspection approach. DWEA has traditionally dealt with specific problems at inspections. One of our hypotheses is that enterprises could reach a higher level of prevention if the inspector focuses on what kind of prevention culture the enterprise has and motivate them to improve it.

In addition to this general hypothesis DWEA has some hypotheses about new useful inspection methods and instruments. But the big question is whether this methods and instruments work in real life and do they have the expected effect?

In the Ministry of Employment it is a common focus to strengthen implementation of our initiatives to ensure even better results of our work. As a result of this focus DWEA has decided to involve enterprises very early in the process of designing new approaches to inspection. We believe that a crucial way to improve implementation is to know our target group better for example: What is important for the enterprises? How do they experience inspections? What is motivating them to improve the working environment?

To find the answers to the questions above we have invited ten enterprises from different industries to help us. They are invited to participate in a workshop where we furthermore want to test our hypotheses about new instruments and methods. The enterprises should tell us what they think about the instruments and

what kind of actions it would launch in the enterprises. Finally they can inspire us to find new ways to improve the instruments to achieve better results.

After the workshop we want to include the enterprises' ideas, needs and experiences in the further process of designing instruments for inspection.

3. Discussion

It is quite new for DWEA to involve individual enterprises so early in the development process but we expect to get a fruitful output. Because of the inputs from the workshop we have a better understanding of our target group and how they typically react. This knowledge gives us the possibility to design instruments that would lead to the change we want to achieve in real life.

At the conference session we will discuss our experiences involving users in developing inspection methods and instruments.

The Organization Makes the Difference

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The Swedish Work Environment Authority has, 2011-2015, been commissioned by the Swedish government to work with women´s work environment. Lessons learnt will be disseminated. A gender perspective in the work with health and safety is important. This can be done by visualising different working conditions, but also by comparing and analysing whether differences are motivated in order to find the most effective measures in preventing ill health in working life.

Keywords: Supervision, Gender, Women´s work environment

1. Introduction

From 2011-2014 the Swedish Work Environment Authority had a special commission from the Swedish government to visualize women´s health in working life and prevent early retirement from work due to problems in the work environment, with an emphasis on conditions related to musculoskeletal health and ergonomics. During 2015, the authority has received a new commission to deal with dissemination of the results and conclusions that the project has resulted in. Focus should be particularly on female-dominated sectors.

Our overall conclusion from the project 2011-2014 is that the following factors are of importance in explaining why women are more likely than men to suffer from occupational diseases:

- There are the same gender patterns in working life as in the society. That women´s work is valued lower means that their risks at work are not made visible and it is therefore that there are not sufficient preventive measures taken. A gender perspective in systematic work environment management is needed to deal with this problem.
- The gender-segregated labour market and differences in work tasks contribute significantly to the fact that women are at greater risk of developing musculoskeletal disorders.
- Many employers and employees lack sufficient knowledge to prevent musculoskeletal disorders in their work organization (Arbetsmiljöverket, 2015).

2. Objectives

The aim of the presentation is to give an overall reflection on the importance for the organization to visualize, compare and reflect in order to take effective preventive measures for a sustainable work environment.

3. Methods

In this session a brief résumé of the project Women´s Work Environment with the results and conclusions will be presented. We will also describe how we, during 2015, are disseminating and implementing the experiences and new knowledge in our own organization and in the work with the stakeholders. Methods used to visualize gender in inspections will be presented.

Five areas are covered in the project: state of knowledge compilation with focus on organisational and social factors, communication, education, inspection and evaluation of the impact on the authority as well as evaluation on the inspections done during the program 2011-2014.

State of knowledge: A review will be published at the end of 2015. The main question is why women have more ill health caused by organizational and social factors than men. This will be important strategic knowledge in the work towards the prevention of women´s ill-health.

Communication: There will be information to and dialogue with different stakeholders through seminars, conferences, and information material. The aim is to disseminate knowledge gained in the program.

Education: Inspectors have to increase their knowledge in areas like organizational and social factors, ergonomics and gender issues in order to inform stakeholders and transform knowledge into practice.

Inspection: The project will support project leaders and participants of planned inspection activities to perform their inspections with a gender perspective.

Evaluation: Analysis and evaluation of the internal and external results of the program 2011-2014 will be performed.

We want to also look forward. Based on the current picture of the problems in women´s work environment, we will discuss the challenges we can see.

4. Conclusions

It is important that the organization takes into account what gender means in the work for health and safety. There is a need to also focus on psychosocial factors. A learning organization has to visualize, compare and reflect in order to take effective preventive measures for a sustainable work environment.

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An approach in the field of cognitive work environment

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Cognition is necessary for all kinds of work tasks and is influenced by all conditions at work place such as physical, chemical, social and organizational. In this presentation Swedish Work Environment Authority (SWEA) wish to draw attention to the importance of accounting for the cognitive aspects of the work environment. We describe the steps SWEA has taken in this field so far.

Keywords: Work, cognition, attention, memory, reasoning, language, provision, standard, inspection

1. Introduction

During recent decades, extensive changes in the characteristics of work environment have taken place. For example, work requirements have transformed from concrete, physical and stable to abstract, continuously changing and knowledge intensive. Further, team work has significantly increased, and self-control and empowerment have replaced supervision and control. Additionally, more psychological, emotional and social skills are needed. These changes also demand increased cognitive skills.

Cognition is a group of mental processes, for example, attention, learning, memory, reasoning, language and executive functions. Gaining knowledge about these functions is a core aspect in increasing awareness of the requirements of modern work and in finding ways to prevent risks for ill health and accidents. Swedish Work Environment Authority (SWEA) has realized that there is a lack of overall knowledge of these aspects in the work environment. Therefore, three researchers were assigned to put together a State of Knowledge Report. The report – Den hjärnvänliga arbetsplatsen (SWEA Rapport 2014:2, The brain friendly working place) - provides an overview of nine different cognitive areas, presents the prevalence of cognitive impairments in employees, describes consequences of cognitive deficits for work and proposes practical solutions.

According to this report as many as 15% of all employees between 16 and 65 years in Sweden may be affected by cognitive deficits. Not only brain related conditions but also many common diseases may lead to cognitive difficulties. In addition, common factors related to every-day life can influence cognitive capacity in a negative way. For example sleep deprivation and stress have been found to decrease the capacity for multitasking already after a few days (Haavisto et al 2008, Sallinen et al 2013). Problems with attention, memory, executive functions and irritability may result. The Brain friendly working place -report also shows that as many as 55% of all employees between 16 and 65 years are expected to develop cognitive problems at some point.

It is important to remember that particular cognitive impairments do not pose the

same problems in all environments. Quite the opposite, the consequences of cognitive disabilities appear in relation with the environment. Even if there are some general functions which are necessary for most work tasks, different tasks require different combinations of cognitive functions. That is why we need to have the work environment accessible for the widest range of people from a cognitive point of view. Only by doing an analysis of what kind of skills are required in a specific work task we are interested in, can we conclude which cognitive functions are crucial for that particular work and what kind of work environment should be preferred.

2. Objective

This presentation describes the approach of SWEA in the field of cognitive work environment. We want to raise awareness of the importance of this field for modern work.

3. Methods

In addition to the Brain friendly working place -report, our approach consists, thus far, of the following steps:

3.1. Education

In educations arranged by SWEA 2012-2014, all its employees, including the staff at the headquarters and the inspectors, received some basic knowledge about cognitive functions. The starting point was spreading information on the significance of attention and working memory because these cognitive functions are typically the first to become overloaded. Being vulnerable, they are influenced by other aspects of work environment such as physical, chemical, social and organizational work environment. This makes the overall picture even more complex.

3.2 Inspections

We have included the cognitive perspective in some of our work environment inspections since 2013, albeit first in a very limited form. The target of these early inspections was the recycling industry. First, we focused on verbal and non-verbal aspects of work instructions. For example, to be accessible for the widest range of workers, verbal instructions need to be written down, read aloud, completed with figures or pictures or be replaced by a video presentation.

The other focus area has been to reduce cognitive load, in any field. In these later inspections, other aspects of accessibility such as physical, psychological and social aspects could be integrated. The primary goal was to inform the employers of and demonstrate the importance of different aspects of accessibility. Below, I present a few examples of how we clarified how to reduce cognitive load. It can be done by

- *Improving the physical work environment*, such as investing in better lighting, air quality or noise reduction which in turn improve conditions for concentration and learning.
- *Minimizing distractions in the social work environment.* A work environment characterized by conflicts and uncertainty impairs conditions for concentration and consequently good work performance. In contrast, when we feel safe and work in a friendly atmosphere, we can listen, learn and think better.
- *Minimizing distractions in the organizational environment.* When the employer clearly indicates the tasks the employee is expected to work with and prioritizes

them, the employee does not need to think whether he or she is focusing on the right tasks and in correct order. Feelings of worry and anxiety as well as other negative emotions increase fatigue. A dialogue between the employer and the employee can save a lot of energy when, for example, the work can be restructured so that all tasks are reasonable and clear.

- *Minimizing demands to multitask.* Our ability to multitask is overrated, and multitasking increases the risk of human errors and fatigue.
- *Reducing cognitive load with effective technology*. User friendly and accessible systems and programs, for example, systems that adapt to individual situations, abilities and preferences, and can be used (as far as possible) without an instruction manual, save working memory capacity. Hassles with technology interrupt one's thoughts and lead to shifting focus from the task at hand to the technical aspects. After every interruption it takes time to regain focus on the task.

3.3. Provisions

When producing or editing provisions and standards, we take into account aspects of accessibility, including cognition. As an example, we have participated in revising the ISO/IEC GUIDE 71, Guide for addressing accessibility in Standards. Its intended audience are standards developers. But this guide contains information that can also be useful to other people who want to learn more about peoples` accessibility needs.

4. Results

We are only at the very beginning of the process of integrating and operationalizing cognitive aspects in the field of work environment. Thus far, we have gained and distributed awareness of the importance and the complexity of this field. We have created routines in order to integrate accessibility into provisions, standards, inspections and communications. We are currently in the midst of working on the appropriate terminology to use when communicating information about the brain at work. Further, we are currently also taking a closer look at the cognitive consequences of digital development at work. In the future, we would also need to learn more about the risks for cognitive effects from exposure to chemicals at the work place.

5. Conclusions

Why is it important to learn more about cognition and to take cognitive demands into account at work places?

Working life has changed to be more abstract, and cognitively, emotionally and socially demanding. We need to recognize the early signs of cognitive load to be able to prevent ill health, but more importantly, to prevent circumstances that predispose employees to unnecessary cognitive load in the first place.

Further, most aspects of the work environment are related to cognition. Cognitive functions, the higher brain functions, are vulnerable to all aspects of the physical, chemical, social and organizational work environment. We also know that mental ill health has increased during the last years, and that it is closely linked to cognitive functions, regardless which kind of ill health we are talking about.

How to get there?

There are big challenges ahead of us. To be able to prevent mental ill health and

accidents at work all of us - researchers, practitioners, and authorities - need to contribute.

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Review of the knowledge concerning the digital working environment and cognitive loads

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Keywords: digital work environment, IT-related change processes, cognitive loads

1. Introduction

In many Swedish workplaces a variety of IT-based systems are used. This in order to share and create information, to communicate and interact between people and activities. According to the Work Environment Survey 2013 approximately 75% men and 81% women uses a computer (desktop or laptop) at work. In average, indications for both men and women, shows about 20% uses the computer constantly. The Swedish Work Environment Authority (SWEA) has clear indications that digital working environment problems increases. So what are the problems, how can the problems be understood, how do they occur and what are the effects? To answer these questions, we gave researchers at the Royal Institute of Technology (KTH) in Stockholm, in cooperation with the University of Uppsala, a mission to collect, review and summarize the knowledge about digital work environment and focusing on cognitive loads. The mission included study of risks of negative effects, such as imbalance between requirements and opportunities but also other conditions that can cause stress at work. Such stress could for example be monitoring of processes and other safety-critical activities. The mission also included to study and summarize the opportunities digitization means. In a draft report the researchers state that there is no current research and knowledge of digital work or digital working environment that is practically useful, because this complex area is neglected and need broader research efforts in several areas of science.

2. Methods

SWEA will present how the research group worked during the process with searching literature, mapping, analyzing and drawing conclusions of the reviewed material.

The researchers conducted two seeking periods (February and April 2015) to collect scientific articles published in scientific journals during the years 2010-2015. They have mainly sought after English literature but also made searches of Swedish databases. After reading and assessment of 1643 articles based on relevance the researchers found that only 36 articles met the selection criteria. Articles were divided into and presented in five broad areas: digitalization, digital work environment, cognition, method and theory.

The researchers also reviewed international and national ergonomics standards that are important for the development, implementation and monitoring of IT. The standards who have been selected for inclusion in the report meets IT use, the quality concept of usability and accessibility.

In addition, the researchers searched for relevant reports from major funders and funded research projects in Sweden to find references to research related to the digital environment. The report will present research that has been conducted via Forte (Research Council for health, labor and welfare), Stress Research Institute at Stockholm

University at the Faculty of Social Sciences, AFA Insurance and the Swedish Innovation Authority; Vinnova.

They also examined studies in industries such as healthcare, banking, insurance companies, call centers, process and control environments. These workplaces have significant digital work environment problems in connection with journaling, case management, frequent and intensive customer contacts, control and monitoring of complex and dynamic processes.

3. Results

The results of the review of research regarding the digital working environment and cognitive loads will be presented at the NES 2015 conference and also at internal and external seminars during the autumn in Sweden. The result of the current state of knowledge and suggestions for proactive measures and solutions, for example in different work environments such as healthcare, administration, and process work will also be published on our website www.av.se.

The research group's literature searching resulted in among other things in a thorough review of current research and knowledge, both nationally and internationally. They note that the area is neglected and need broader research efforts in several areas of science. They describe how a number of different branches and trade unions work with surveys and studies of the digital work environment of importance for workers and business economic aspects.

4. Discussions and Conclusions

The research highlights that the area's complex nature creates special challenges for the research and there is need for development and new thinking. They consider that traditional research disciplines within work science and engineering sciences need to work together to get the work environment perspective to meet the business community´s and public sector´s expectations for digitization significance for working life. They call for more research works in research funded activities to study the effects of digitization in employment. In the report it is argued that *"digitization leads labor to many changing conditions for the digital work environment; works fundamentally change, organizations change, technology evolves, the requirements of efficiency, quality and boundlessness of changing all the time. The need to focus research and development on digital work environments and digital work environment problems increasing all the time"*

Children's use of handheld digital devices – how to prevent eyestrain and musculoskeletal complaints?

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1. Introduction.

This is a review – and a starting point for a discussion about the importance of this issue. Children's use of digital devices, at school and leisure, has exploded the last years, and there is a trend for increased use of handheld devices, such as computer tablets and smartphones [1]. In Norway in 2014, over 80 % of children aged 1 – 12 years had access to computer tablets, and 75 % of 9 – 12 year olds had their own smartphone [2]. In Norwegian schools in 2013 about 15 % of 12-year olds used computer tablets for classwork / homework [1].

2. Current situation.

Children using smartphones have increased risk of dry eyes, tired eyes and headache, and children using computer tablets have less neutral spinal posture, more elevated scapular posture and greater upper trapezius and cervical erector spinae activity [3, 4]. This is in accordance with studies in adults showing unfavourable positions of head, neck and wrist when using computer tablets [5, 6]. However, the computer tablet invites to greater variability of posture and muscle activity, compared to a stationary / laptop computer [4]. Additional, smartphones tend to be held closer than the typical near working distance of 40 cm. This places increased demand on the visual system, both on accommodation and convergence [7]. Increased visual demand is associated with increased symptom development of eyestrain and musculoskeletal complaints [8-13].

3. Research.

To our knowledge, no studies have investigated the use of handheld digital devices in relation to musculoskeletal symptoms in children. In addition, there seems to be little awareness in the public about the association between using the eyes / visual anomalies and musculoskeletal complaints. This calls for increased research and communication about these issues.

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Visual and Psychological Stress during Computer Work

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Keywords: *Computer work, Orbicularis oculi, Trapezius, Visual stress, Glare, Psychological stress*

1. Introduction.

Studies have shown associations between eyestrain and musculoskeletal pain in the neck and scapular area (Helland et al., 2008; Lie & Watten, 1987, 1994). In line with this, there are shown correlations between visual unfavorable conditions and stabilizing muscles in the neck and shoulder area during computer work (Richter, Banziger, & Forsman, 2011; Richter, Zetterlund, & Lundqvist, 2011; Zetterberg, Forsman, & Richter, 2013).

In a previous study, we showed that exposure to visual stress introduced as glare during reading on a computer screen affected both eye-related symptom development, eye muscles (orbicularis oculi) and head-stabilizing musculature (trapezius), compared to reading under appropriate lighting conditions [paper submitted]. To further elucidate how glare affects symptoms, orbicularis oculi and trapezius, we wanted to examine these muscles during both psychological stress and visual stress (glare). Psychological stress is previously shown to increase trapezius muscle blood flow and muscle activity (Larsson, Larsson, Zhang, Cai, & Oberg, 1995; Lundberg et al., 2002).

The present study investigated how visual stress, introduced as glare, and psychological stress influenced m. orbicularis oculi, m. trapezius, subjective affect states and symptoms during computer work.

2. Methods.

2.1. Subjects

Twenty-four healthy, young women (22 ± 2 years, mean ± SD) with normal binocular vision were included in the study.

2.2. Design and procedures

All testing was carried out at the same optimized computer work place. Four different computer work sessions with different stress exposures were performed: 1) Low stress, LS, 2) Visual stress, VS (glare), 3) Psychological stress, PS and 4) Visual and psychological stress, VPS. The psychological stress in PS and VPS was induced as time and efficiency pressure, filming during the conditions and questions from the text after the conditions.

We used a counterbalanced design. The assignment in all four conditions was proofreading using a regular mouse as input device. Each session lasted for 10 minutes with approximately 15 minutes breaks. Psychological stress in PS and VPS included time and efficiency pressure, filming during the sessions and control questions from the text read. Muscle activity and muscle blood flow in dominant m. trapezius and muscle blood flow in m. orbicularis oculi (dominant eye) were registered continuously during computer work and rest recordings. Muscle blood flow and muscle activity were measured using photoplethysmography (PPG) and electromyography (EMG), respectively.

Sitting posture was continuously registered using inclinometers on the head and back. Productivity, accuracy, blood pressure and heart rate were also registered. Subjective symptoms and psychological stress indicators, such as affect states, were recorded using VAS-scales before and after each condition. The subjects' positive and negative affects during computer work were registered to measure the subjects' own perception of the task and their performance during computer work.

2.3. Statistics

Overall differences between the conditions and overall temporal changes were tested by repeated measures ANOVA. If significance was indicated, differences at each time point were tested by Paired-Samples t-test or Independent-samples t-test. Pearson correlation was used to examine correlations between different variables. A statistical difference was accepted at $P < 0.05$ (two-tailed). Statistical analyses was performed in PASW Statistics 17.0 (SPSS Inc., US).

3. Results and discussion

Preliminary results shows that the subjects felt significantly more uncomfortable during the two glare conditions (VS and VPS), compared to during computer work with low stress exposure (LS) (VS vs LS: ($t(23) = 2.691$, $p = .013$), VPS vs LS: ($t(23) = 3.014$, $p = .006$). They also felt more uncomfortable during the condition with both visual and pshychological stress (VPS), compared to psychological stress exposure (PS) ($t(23) = 2.559$, $p = .018$).

The subjects experienced the ambient lighting significantly more uncomfortable during both VS and VPS, compared to the two conditions with appropriate lighting, LS and PS. (VS vs LS: ($t(23) = 13.283$, $p = .000$), VPS vs LS: ($t(23) = 12.791$, $p = .000$), (VS vs PS: ($t(23) = 9.746$, $p = .000$), VPS vs PS ($t(23) = 9.995$, $p = .000$)). Interestingly, the subjects also perceived ambient lighting significantly more uncomfortable when exposed to both psychological stress and glare (VPS), compared to only glare exposure (VS) ($t(23) = 2.373$, $p = .026$).

Preliminary results from the current study also show significantly overall increased trapezius muscle activity when exposed to glare and psychological stress simultaneously (VPS), compared to the low stress condition (LS) (static level: ($F(3,24)=2.705$, $p= .048$), median level ($F(3,79)=2.833$, $p= .032$))

Acknowledgement

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One-handed use of large smartphone screens.

-An EMG study of ergonomically challenging interfaces.

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Extensive one-handed use of smartphones has potential health risks like repetitive strain injury (RSI), which is caused by static, repetitive movements over an extended time. In this study we have investigated how better designs of todays large smart-phone displays may be helpful to reduce this health risk. The study used Electromyography (EMG) was used to measure muscle activity when interacting with the different screen layouts. The results show a significant correlation between a user interface that applies the functional area and a decline in muscle activity. However, the decline in muscle activity only occurs when the functional area is designed specifically for the user's dominant hand.

Keywords: Smartphones, EMG, Design, Usability

1. Introduction

People tend to use their smartphones one-handed, which is unergonomic for the human musculoskeletal system. Stretching the thumb to reach certain touch keys is uncomfortable. Especially now that smartphones have large screens, normally ranging from 4.5" and above. Exaggerated use of smartphones can lead to repetitive strain injury (RSI), which is caused by static, repetitive movements over an extended time.

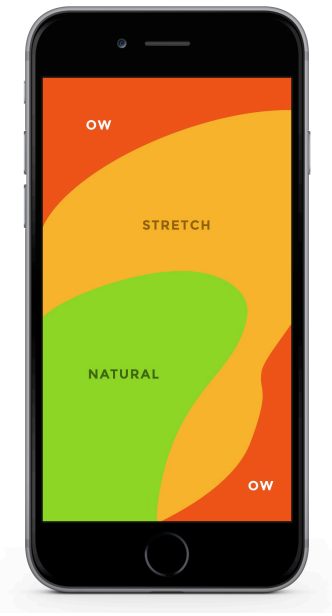


Figure 1: *An estimated functional area for the iPhone 6. Source: Scott Hurff (2014)*

Several researchers have done usability studies as well as theoretical analyses of functional areas for one-handed use of smartphone displays. This project investigates how different touch key locations affect the ergonomics of user interfaces on large smartphones. Moreover, it examines if the principles of the functional area improve the ergonomics of mobile user interfaces. The functional area is the surface of the touchscreen that is reachable by the thumb.

As the majority of the people prefer to interact with their smartphone one-handed (Karlson,Bederson&Contreras-Vidal 2006), some designers have been aware of the thumb's reach limitations. Luke Wroblewski (2011) has written a book about user experience for smartphones, called Mobile First. According to Luke Wroblewski, a user interface needs topay attention to the functional area of the thumb when designing for one-handed thumb interaction. If a user is holding a mobile device with the right hand, it is uncomfortable to stretch to the upper left corner, and vice versa for left-handed people.

The functional area is individual from user to user and is affected by the physical dimension of the mobile device (Bergstrom-Lehtovirta&Oulasvirta 2014). There is no single functional area that fits everyone. However, estimated functional areas following the principles from Luke Wroblewski (2011) and Bergstrom-Lehtovirta and Oulasvirta (2014) can be found for different devices. Figure 1 shows an estimated functional area—the green field—

for the iPhone 6, which has a 4.7" screen, made by the designer Scott Hurff (2014) and published on his blog.

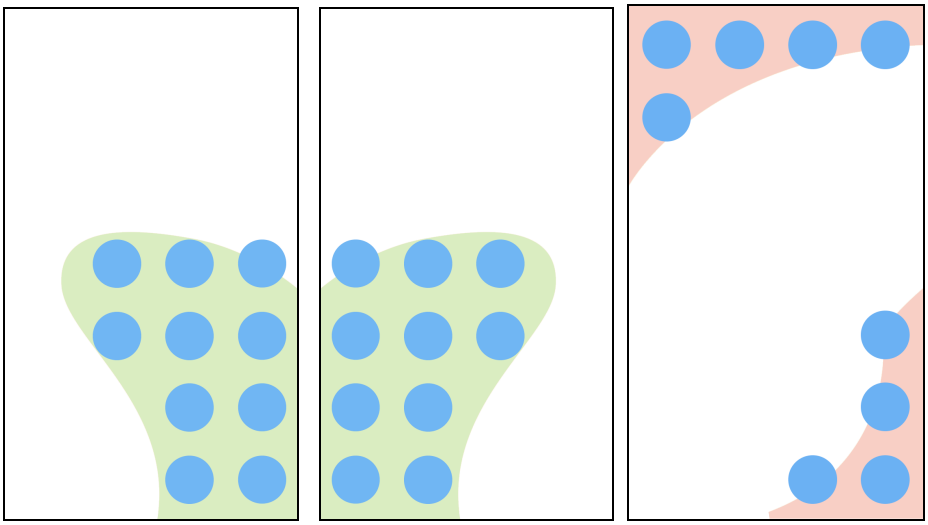
In this study we wanted to investigate if designs based on functionality analyses, had positive effects not only on perceived usability, but also on measurable muscle activity. We expected to find significantly lower muscle activity interaction took place within functional areas, compared to non-functional areas.

2. Method and Apparatus

The experimental procedure in the study was adopted from Choi et al. (2013). They analyzed the discomfort of different touch key locations on a digital keyboard on smartphones, and applied EMG in their study. They measured four different muscles; abductor pollicis longus (APL) and extensor digitorum communis (EDC), which are on the forearm, and abductor pollicis brevis (APB) and first dorsal interossei (FDI), which are part of the thumb. In addition to EMG, the Borg Scale (Borg, 1982) was used to measure subjective discomfort.

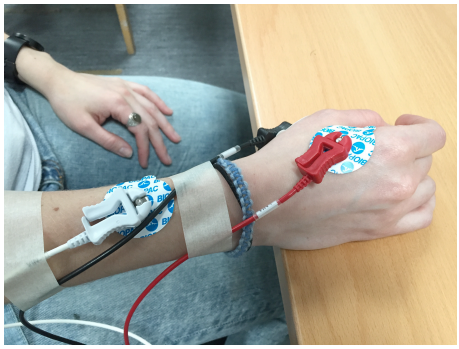
The tasks applied in the test were inspired by the multi-directional tapping task proposed by the ISO 9241 standard. The ISO 9241 standards cover the ergonomics of human—computer interaction. The ISO 9241-400 is a set of "principles and requirements for physical input devices," including touchscreens (ISO 2007).

The 11 participants (6 male, age 23-26) in the study where instructed to hold the mobile phone one-handed with their dominant hand, and push targets when they showed up on the screen. The three tasks (dominant-functional, non-dominant functional and non-functional) where presented randomly, and each of them consisted of 20 targets.



Figur 2 *:The three tasks with target points: Functional area left-handed, Functional area Right-handed, Non-fuctional area.*

Stimuli where presented on an Iphone 6 with a 4,7” screen. Not the largest screen availiable, but considered a good representation for “large smart-phones”.



Figur 3 : *Electrode placement*

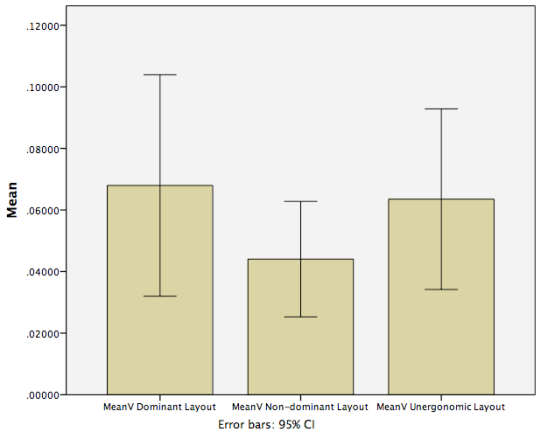
A surface EMG machine was applied to measure muscle contractions, Biopac MP36. Biopac Student Lab 4.0 was used for data recording and processing.

Three electrodes where used, placed on the participant’s abductor pollicis brevis (APB), abductor pollicis longus (APL), and first dorsal interossei (FDI) on the participant's dominant hand. All these muscles were also measured in the related study by Choi, Park, and Jung (2013).

Since physiological responses are individual (Bloom et al. 1976; Hautala et al. 2006), each participant went through all conditions. Individual differences in muscle recording would therefore not affect the overall results. The values of muscle contractions from each participant were combined before the analysis. The muscle contractions were measured in millivolt (mV). An RMS was derived to the raw EMG data to make it easier analyzable. The data was analyzed through SPSS for OS X. The analysis applied two different statistical methods for different purposes: paired-samples t tests, and multiple-level, repeated measures ANOVA.

3. Results and conclusion

The EMG data shows that there are statistically significant differences in muscle contraction between GUIs based on the functional area compared to the unergonomic area. However, the results show that the functional area exposes statistically significant less muscle contraction than the unergonomic area only if it is *properly* designed for the user's specific dominant hand.



Figur 4 : *MeanmV for the three conditions*

"Functional area, dominant" (FAD) and "functional area, non-dominant" (FAN) were compared to see if muscle activity was different for these two mirrored designs. The analyses supports this, but interestingly not in the expected direction. FAN came out with significantly lower muscle activity than FAD ($t = -2.234$, $P < 0.05$). Borg Scale shows no difference between FAD and FAN, but both these comes out much better than the non-functional condition ($F=6,96$, $P < 0.01$).

Why the design for non-dominant came out best, is not investigated enough in this study. Nevertheless we can speculate, and a possibility is that some of the target-points described as functional in the theory we have based this on, actually are ergonomically troublesome. This is targets low-far away on the screen. Interestingly, this is also where we find a lot of interaction on todays mobile interfaces. So to conclude on this: central areas of the screen is safest, high and low are risky.

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Activity in four muscles during email work with computer, smartphone and smartphone with ergonomic recommendations

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The study's aim was to compare muscle activity during computer work with smartphone work and to see what possible effects ergonomic recommendations for smartphones has on muscle activity. Activity was measured bilaterally from the upper trapezius muscle and from lower arm muscles on the right hand side, on twelve participants, with surface electromyografi during simpler work with computer, smartphone in optionally way of working and smartphone with ergonomic recommendations. Activity in m.trapezius and m.extensor digitorum was significantly higher at computer work ($p<0.05$) and activity in m.interossei dorsalis 1 was significantly higher in the smartphone work ($p <0.05$). Comparison of smartphone in optionally way of working and smartphone with ergonomic recommendations showed no significant differences. As a variation of work postures has been forward as beneficial, the results indicate that replacing the computer for a while with a smartphone may give the trapezius muscle an opportunity to rest.

Keywords: Muscle activity, smartphone, electromyografi, ergonomic recommendations

1. Introduction

Musculoskeletal disorders in the neck, shoulders, arms and hands can occur during prolonged static muscle activity such as in computer work (SBU 2012).The use of smartphones has increased lately and the new technology also enables greater flexibility in the work of many professions. The majority of office workers now have access to a mobile phone with internet access (Unionen 2011). A smartphone today has features similar to those of a computer and the work has low-intensity and repetitive characteristics.

Gustafsson et al have studied work techniques in the use of mobile phones (Gustafsson et al., 2011), and made a list of ergonomic recommendations for mobile use; support the forearms, use both hands and work with the screen in an appropriate height (Gustafsson 2012). These recommendations are also found in the existing ergonomic recommendations for computer work (Arbetsmiljöverket 2012).

The aim of this study was to compare muscle activity during computer work with smartphone work and to see if the suggested ergonomic recommendations for mobile phones have an effect on muscle activity.

2. Objectives

Twelve volunteers participated in the study with a median age of 31 years (25-34). All were perfectly healthy with no symptoms of the upper extremity. They were right-handed and daily users of both computer and smartphone (iPhone).

3. Methods

Muscle activity was sampled (1024 Hz) with surface electromyografi (EMG) in four muscles;

right and left m. trapezius pars descendes located in the neck/shoulder, right m. extensor digitorum of the forearm and right m. interossei dorsalis 1 of the thumb located between the thumb and forefinger.

The maximum voluntary electrical activation (MVE) was measured during maximum voluntary contractions (MVCs) for each muscle (Gustafsson et al., 2011). EMG was recorded during email work with computer, smartphone in the subjects own way of working, and smartphone with the suggested ergonomic recommendations according to Gustafsson (2012). Each measurement lasted for 5 minutes and the EMG-signals were observed for quality in real time during each measurement.

The EMG was filtered 20-400 Hz, RMS-transformed (8 Hz), and normalized to the subject's MVE. Data were analyzed separately for the 10^{th} (the level of static muscle activity) and the 50^{th} percentiles were computed for each subject, trial, and muscle (Thorn et al., 2005).

Paired t-test comparisons were made of the EMG levels between computer and smartphone, between computer and smartphone with ergonomic recommendations and between smartphone and smartphone with ergonomic recommendations. The level of significance was set at $p<0.05$.

4. Results

All subjects completed the study (n = 12). EMG-signals were clear and free from technical artifacts for all subjects.

The muscle activity in m. trapezius bilateral and m. extensor digitorum was significantly higher in computer than in smartphone work ($p<0.05$), while the muscle activity in m. interossei dorsalis 1 was significantly higher in smartphone work ($p<0.05$).

Comparisons of smartphone and smartphone with ergonomic recommendations showed slightly higher muscle activity in the smartphone work with the ergonomic recommendations, but the differences were not significant.

5. Discussion

The results of this study showed higher muscle activity in the neck/shoulder and forearm in computer work in comparison to smartphone work, and that for the muscle activity of the thumb, the contrary, a higher level in smartphone work.

The number of muscles measured was limited to four muscles for practical reasons. The muscles were chosen because they are commonly studied during repetitive work (Gustafsson et al., 2011 and Thorn et al., 2005). Also because it is common for pain caused by low-intensity repetitive work, such as computer work, to include the upper trapezius (Mork and Westgaard 2007). If the election of other muscles had been made differently, other results may have been obtained.

At the smartphone work in this study the subjects sat to a large extent with the neck bent forward and the arms along the body, which may have led to a more relaxed trapezius but may instead have demanded an increased activity in the deeper muscles or other structures that stabilize the upper extremity.

Most subjects used both hands during the smartphone work, even when sitting in their own way of working, which could explain the lower muscle activity in the right extensor digitorum both in the smartphone work and in the smartphone work with the ergonomic recommendations compared with the computer work in which all used the computer mouse in the right hand.

The participants were instructed in the ergonomic recommendations just before the measurements and it may have been that the muscle activity increased when the participants got new instructions and had to sit in a way that they were not used to. If they had been able

to practice with the ergonomic recommendations for a longer period maybe the results would have been different.

If there had been more participants, it may have led to different results, especially when comparing smartphone and smartphone with ergonomic recommendations where the differences were not significant. As the twelve subjects, in this paired comparison, are used as their own controls, the power becomes larger than when using the mean values of different groups. Similar EMG studies have used a similar sample size (Thorn et al., 2005 and Arvidsson et al., 2006).

6. Conclusions

Varying working postures are an important aspect to avoid work-related disorders and variation of postures could even in this case be beneficial. The study indicates that the muscle activity in the neck/shoulder and forearm are higher in computer work and muscle activity of the thumb on the contrary, is higher in smartphone work. To replace the computer for a short while to work with a smartphone should there for be a benefit for a variation in muscle activation patterns where the trapezius will have an increased opportunity to rest. More studies on ergonomics and smartphone work are needed.

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Social Interaction in Activity Based Workplace Concepts

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Activity based workplace concept may increase employee and manager ability to control and handle social interactions in the office. This due to increased possibilities for applying privacy mechanisms according to: social rules, moving away from the context, structuring different activities in time, creating spatial separation, and by using physical devices to control social interaction. Semi-structured interviews with a total of 86 employees provided the main bulk of the data. The different areas, zones spaces and tools provided employees and managers with new resources to use. The findings however indicate that managers and employees use different strategies, this especially to handle unwanted interactions.

Keywords: Activity Based Working, Privacy, Control, New Ways of Working

1. Introduction and Objectives

New ways of working with focus on mobile, flexible and distributed work processes, as well as new technological innovations, are changing the modern workplace. In this process, more and more organisations have started to emphasise that 'work is not a place, rather a state of mind' (Skjæveland, 2012; Bakke, 2007). Here, the physical workplace is designed and deployed as a strategic instrument with the intent of 'changing minds'. This has resulted in a change in how organisations think about and design their workplaces, – often leading to new contemporary and activity based workplace concepts planned to increase spontaneous interactions, collaboration and knowledge sharing. Going from traditional workplace concepts, focus is put more and more on autonomy and individual choice over how and where to conduct different work tasks, – both within and outside the office building (Robertson et al., 2008; Lee and Brand, 2005). By providing employees with control over their work environment, the organisation allows them to self-manage the work situation, modify features in response to work flow, tasks and job demand and influences decisions on where and how to conduct work (O'Neill, 2007; O'Neill, 2010).

For employees and managers, new workplace concepts often result in radical spatial changes as well as expectations to adapt to new ideas. Especially the introduction of activity based workplace concepts, supported by free seating and clean desk policies, require organisations and individuals to start to explore new ways of working, learn new skills, change their routines and the way they interact with others in the workplace. Thus, employee and manager ability to handle work related demands, control social interaction, structure own work processes and learn how to cope in the new office environment is highly important.

Within the workplace, control of unwanted interaction is particularly relevant. Employees assess privacy at the functional level in form of 'architectural privacy' – (separateness and freedom from distractions provided by boundaries in the environment) and in form of 'psychological privacy' (exclusivity, status in the organisation and sense of control over information and environmental control). Architectural privacy contributes to psychological privacy by control of accessibility of others (Vischer, 2005; Sundstrom et al., 1980).

According to Rapoport (1980), privacy may be controlled through; *rules* (manners, avoidance, social hierarchies etc.) making unwanted interaction in a specific context impossible, *moving away* from the context (literally or by internal withdrawal), structuring different

activities in *time*, through *spatial separation,* or *physical devices* such as walls, doors, etc. How such mechanisms work is dependent on the culture and clarity of cues in the setting (Rapoport, 1980). In cellular office workplaces a common way of controlling privacy is carried out by closing the door, – sending out a privacy signal to the surrounding (Baldry and Barnes, 2012). Thus, going from a cellular office workplace to an more open and activity based workplace concept, can result in a loss of both architectural and psychological privacy (Vischer, 2005).

However, Laing et al. (1998) argue that employees with greater level of work autonomy and more varied work processes are likely to spend more time away from the desk and work in several locations – this both inside and outside the office building. Such flexible use of space may provide employees with a greater degree of autonomy regarding factors such as timing, content, tools and locations of work, thus providing more resources to handle and structure social interaction (Laing et al., 1998; Van der Voordt, 2004; O'Neill, 2010).

2. Methods

The study explores how managers and employees in two larger Norwegian organisations have learned new skills and changed their strategies for handling own and collaborative work processes, this due to introduction of an activity based workplace concept. The two organisations are located in the same business district and houses approximately 800 employees respectively. The activity based workplace concepts in the two organisations were structured based on free seating and clean desk principles. Both offices had public areas with spaces for meetings and interactions with externals, semi public areas such as lunch places, social meeting places and internal meeting rooms and private areas with smaller multifunctional rooms, project places and workspaces assigned to different departments or groups. Both offices also had a separate quiet area or 'library' where employees could go to conduct concentrated work.

The discussion is based on 50 semi-structured individual and group interviews with a total of 86 employees and managers from the two organisations. Observational studies as well as analysis of secondary material in forms of organisational evaluation surveys were also conducted. Work processes varied amongst the employees, this especially with regards to mobility, autonomy, routines, responsibility, costumer interaction, individual and collaborative work. Data from the interviews were analysed by coding the findings into the main five categories of privacy mechanisms, according to Rapoport (1980).

3. Results

Employees at both organisations report a high level of satisfaction with their new workplace concept. Internal quantitative evaluation studies from both organisations also indicate increased environmental satisfaction levels. Employees were especially positive regarding the aesthetic appearance, the flexibility, different areas and tools to choose from to conduct work and freedom to do so. Also work in open landscapes was reported to support social work processes, knowledge sharing and learning. Mobile work was reported to enable more impulses and create more possibilities for interaction as well as a more varied workday.

The activity based workplace concept provided employees and managers with more resources to use in order to handle social interaction. The findings illustrate a shift in strategies for controlling social interactions, going from behavioural rules and physical devices, to use of strategies such as moving away from the context and structuring activities in time. In the old workplace concept, where employees were assigned own desks, the most used strategy to control social interaction was found to be behavioural rules and spatial devices. Spatial devices such as closing a door to the office or putting on headphones were used most frequently. In the new workplace, the strategy of literally *moving away from the context* was reported to be used the most to control social interaction. This was often done with the motive of hiding away when doing individual work in times of high pressure. Managers especially had a lot of responsibility

with regards to inquiries and questions from co-workers, and often used this strategy to control employee accessibility and balance the workday. *"Out of sight, out of mind – you may be anywhere in the world. If I work from another floor, from home, from London or from a client's office – nobody knows. However if I am at the floor assigned to my department people come up to me all day"* (middle level manager). Spaces such as meeting rooms, quiet areas, the 'library', a corner in a social area or a desk at another floor or department were often used for this purpose. Working from home or outside the office was also used for this purpose. However, wanting to be close to co-workers and available for inquiries, some leaders and managers deliberately chose to work either close to their department or at a visible place close to main communication paths. These managers tended to conduct concentration-demanding work at home or worked from other locations outside the office. Some occasionally also preferred to work in a lounge area or from the central coffee bar. Such places were chosen to be social and non-social at the same time. Here employees had the possibility to get away from their own department but still run into people, collaborate or work in a place surrounded by other employees from the same company. *"As long as there is room I don't feel the need to work from the same place every day. Some times I want to work close to one person, another time I need to work close to another. Some times I just feel for some variation… Previously I had to work from home a lot to be able to concentrate. Now I just go to the quiet place when I need to"* (employee). Employees with more mobile work patterns also reported higher levels of spontaneous interactions with people outside their immediate work environment.

Prior to the transition, both organisations had to some extent addressed managers and invited them in discussions on how to behave and act in the new workplace, this with the intention of 'changing minds' through leading by own actions as a form for 'management by walking'. Although some lower level managers state that they were sceptical towards the new workplace concept, most of them stated that in the beginning they tried to be true to the concept and the company's intentions. At both locations employees report that managers and especially the top-level management had become more visible and actively involved since the transition to the new workplace. In this respect, one manager mentioned that he deliberately had started to choose unusual places; this was to move away, create variation and a 'new context' for a routine work process. This leader had for example started to conduct employee development meetings in a 'private' corner in the lounge area by the main coffee bar. The manager experienced that the change of context made the conversation more relaxed and also more efficient. Here, the manager also used the strategy of separation of activities in time, this as the meeting was booked early in the mooring or late in the afternoon, when few people were around.

Structuring activities in time was an often-used privacy mechanism. Due to the transition to a new workplace, most employees had been moved to larger open plan environments shared with other departments. Working close to other departments seemed to affect team communication and socialising. As a result some employees experienced a reduction in 'small talk' while others felt that it was more challenging to make phone calls. Thus, some tried to make phone calls early in the morning or later in the afternoon when the landscape were not that crowded. Others chose to go into an adjacent room, here moving away, or even wait to make sensitive phone call until they got home. Due to pressure on meeting facilities some employees conducted meetings early in the morning or late in the afternoon when the facilities were emptier. This eased handling interaction with externals without getting distracted by internal collaboration processes and activities. The strategy of separation of activities in time also functioned as a cultural informal rule at lunchtime. In one of the organisations, higher-level organisational members had a culture for having lunch later during the lunch service, when the lunch area weren't that crowded. Thus, some employees also went later to lunch, this was done to increase the chances of accidentally bumping into a manager to ask a question that one did not want to send by e-mail.

The need for *rules* to manage social interactions and especially sound levels in the workplace had to some extent diminished due to the transition to an activity based workplace concept. Rules in the new workplace concept were mainly structured according to acceptable

behaviour in different zones. The new rules placed focus more on emphasising that social interactions were not prohibited, rather allowed and appreciated, this especially in the common social interaction spaces. However, informal rules and cultures are often difficult to change. Thus, although rules for the new workplace concept were created in advance old habits, rules and social hierarchies were also brought to the new workplace. Especially some cultural norms seemed to prevent employees from utilising the public and semi public social places intended for social interaction, communication and collaboration. In the months after the transition, many had the idea that working from these places was by others seen as 'being lazy', 'taking a lot of breaks' or 'not working'. *"I get a little worried when I work or collaborate with others in the social areas. What do others think about me then, – does she work or are she just wasting time?"* In an attempt to change this norm, managers at one organisation had put up signs with words and statements emphasising social work processes. In addition these managers had deliberately started to spend more time in the social areas. Ultimately, by their use of space created a new statement. These strategic choices had a positive effect and shortly afterwards employees also started to use the social areas to conduct different work processes.

The free seating structure allowing anyone to chose any desk was a central rule implemented at both organisations. However, as some individuals repeatedly chose the same desks day after another informal rules were created, restricting other employee categories to choose certain places. Especially where groups of managers had located themselves, informal hierarchical structures had materialised. Here, the strategy for handling social interaction in form of *spatial separation* comes into play. Occasionally, managers may need to be fully or partly separated from employees, this in order to be able to handle social interaction with other managers. Sensitive discussions amongst managers were mainly conducted away from the core department, at more private locations in the office or when employees were not around.

The use of *physical devices* to control social interaction had somewhat decreased and been replaced with the other strategies. However, at some departments, especially by those where employees did not use as many of the other strategies to handle social interaction, there was still a strong wish for more possibilities for separating individuals and groups with physical devices such as doors, flexible dividers and walls. At some locations, storage cabinets or other physical devices had been placed in the open area to divide groups and signal group belonging. Some employees also mentioned that they often used headphones – some times even without playing music – this to signal that they did not want to be disturbed. For the employees and managers that previously had worked in cellular offices, the ability to have informal and spontaneous meetings in the office and close the door was lost. Some experienced that this had made spontaneous interaction harder and that it was more difficult, as they did not have the possibility to just drop by a managers or colleagues office. Several employees and managers had however started to solve this by using the organisations chat messaging software. Thus, they began using physical and technological devices to send a short message asking if the other person had time for joining in on a short talk at another location in the office.

Although all employees reported that they used one or several of the five privacy mechanisms, some managers and employees were seen to have developed a wider range of individual strategies and in a better way learned how to utilise the workplace to handle and control individual and social work processes. For these employees the different privacy mechanisms were used not only in order to diminish social interaction but also in order to increase and support social work processes. On the other hand, other employees seemed to have clung to old and 'ineffective' ways of handling social interaction. Employees with fewer strategies also seemed to be less satisfied with the new work environment, stating that the workplace did not fully support work processes such as concentration and individual work processes.

4. Discussion and Conclusions

The activity based workplace concept is substantially different from many traditional workplace concepts. As some employees suggested, the new concept makes it possible to better structure and plan the workday. Thus, with the freedom, flexibility and technology to utilise different spaces, new resources to handle social interaction also increased, providing employees with greater opportunities to handle social interaction the way Van der Voordt (2004) and Laing et al. (1998) suggested. In activity based workplace concepts employees may freely choose from the five privacy mechanisms defined by Rapoport (1980). For many, the new concept was seen as a positive change that increased their own possibilities to control unwanted social interaction. However, for those that did not change their strategies, the environmental control level was seen to have been decreased, ultimately resulting in dissatisfaction with the workplace concept.

Some employees and managers were seen to use the facilities differently than originally expected, – or not to use the resources provided by the facilities at all. In order to create well functioning workspaces, organisations and workplace consultants need to better understand what kind of control behaviour is wanted and why. Furthermore, in order to fully act on the idea that 'work is not a place, rather a state of mind', the organisation and its members need to change and challenge the cultural and organisational behavioural norms and develop new structures for interaction, while simultaneously maintaining and building on familiar ways to behave. The fact that some employees did not choose to use the full range of privacy mechanisms available, although organisational policies and modern technology supported employees to do so, may also reflect a lack of knowledge of what resources are available to use. Here, existing cultural norms and old ways of doing things may restrict employees in fully utilising the opportunities provided by the new workplace. O'Neill (2010), argues that management and the influence of organisational policies, technology, and training are important factors in order for employees to adapt to new behavioural norms such as applying specific control behaviours. As some employees and managers gradually started to experiment with the new workplace and try out new strategies for handling social interaction, their own – but also others – 'environmental competence' level increased. Thus, visual trial and learning activities related to use of space is essential in developing a broad base of resources to use for handling social interaction. By continuously doing so, employees and managers may develop a broader range of architectural privacy, ultimately supporting psychological privacy the way Vischer (2005) suggests.

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Leadership behaviour, stress and productivity

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The paper discusses leadership functions in modern organisations and its connection to followers` stress and the organisations productivity. The literature connecting leadership to stress is somewhat sparse. The paper contributes to the literature through an analysis of leadership and stress among 3.400 employees in a public organisation. It argues that leadership is many faceted and have both direct and indirect impact on followers as well as the organisation.

Keywords: Stress, leadership

1. Introduction

Leaders generally receive much attention in our time. Successful leaders are cheered and discussed in business magazines and newspapers. Their performances in skiing and cycling events get seen as a sound coupling of physical and mental prowess. The less cheered leaders, like cartoon character Dilbert's pointed haired boss, are discussed and shared in e-mails and on internet between a plentitude of disgruntled employees.

The leader is expected to have an impact on each and every subordinate, directly or through different acts of hierarchical management, in order to trim individual performance for the better of the organization (or in some cases – for oneself).

2. Recent reflections on leadership in Norway

The ever pertinent question about leadership is "What do we need leaders for?" Klemsdal (2013) states that the answer is: to do development leadership ("utviklingsledelse"), defined as the art of leading the small but continuous steps of development that we do in everyday life in order to make our work situation coherent and functionable, or to handle the complexity of modern everyday (work) life.

Klemsdals "complex situations" do not necessarily contain more complexity than the dilemmas of a home aid who comes to a home with a list of what to do, and meets a pensioner or patient who expresses other needs or desires that those foreseen by the leader. Daily dilemmas constitute a potentially stressful situation for the employee. In this perspective, the link between elements and quality of leadership on one side, and employee stress becomes obvious.

Organizations are expected to be able to solve such dilemmas by good leadership, and thus contribute to employee health. Slinning and Haugen (2011) scrutinize the leadership of several Norwegian top leaders, looking for what constitutes a health promotional leadership (Slinning & Haugen, 2011). Their aim is to find elements of leadership from Norwegian organizations that aim at creating economic profitability, employee and customer satisfaction.

Despite no systematic summing up of findings; dealing with the totality of individual human sides and needs of each employees and making a best possible match between individual, tasks and

organization, nevertheless seems to be a reasonable summing up of its message. This seems to cover the systematic approach in the Leader-Member Exchange theory.

Nordrik and Bjerke (Nordrik, 2012; Nordrik & Bjerke, 2009) point out methodic difficulties in leadership assessment, and the fact that some organizations react adversely to negative feedback from employees to leaders, thus silencing the voices that could be used to improve leadership, employee satisfaction and efficiency through one common measure: stress.

Stress research and leadership research is seldom coupled. In stress research we are most often interested in the stress process – which factors contributes to the ill health and what moderates them. In leadership research the interest lies in the motivational factors leading to productivity. The Job-Demand-Resources model gives possibility to integrate these points of departure (Bakker & Demerouti, 2007). The model conceptualizes two processes that are closely linked together – one leading to bad health and one process leading to productivity. We wish conduct an analysis of leadership and its influence on both motivational and health factors. Although the leadership factors in this analysis are well known and prominent, they show that the direct impact on motivation and health is limited. The presentation discusses the findings and possible explanations.

2. Theories of leadership

Leadership theories usually are have focused on the motivation of the employees and indicators connected to productivity (e.g. Yukl, 2012). They rarely seem to show profound interest in the health of the employee. Some leadership dimensions however are of particular interest for the stress process: empowering leadership, just leadership and support from leader.

“Support from leader” is well known in leadership research as an effective ingredient of leadership. Support from leader is well known in the literature for moderating perceptions of strain either as emotional support or as practical support (Viswesvaran, Sanchez, & Fisher, 1999). Leaders have the authority to regulate manpower, job-demands, to clarify roles and deal with role conflicts among subordinates.

The core of empowering leadership is transfer of power from top management to knowledge workers with high autonomy, who are able to take initiative and make decisions about daily activities. Employee empowerment involves enhanced individual motivation at work through the delegation of responsibility and authority (Amundsen & Martinsen, 2014). Empowering leadership is linked to control which is a crucial element in Karasek`s stress concept as well as other stress theories (Karasek, 1990, Siegrist, 1996).

Being perceived as just is also important in leadership. Unfair treatment of followers decreases followers` motivation. Just leadership affects in direct and indirect ways, through perceptions of perceived organizational support, the quality of relation with the employee and trust (Colquitt et al., 2013). The same theme has been thematised in organizational health psychology by Siegrist in his Effort Reward Imbalance theory (Siegrist, 1996). If the employee feels that there is no fair balance between his efforts and the rewards he gain, this will affect his health If the employee’s sense of fairness regarding to rewards for his effort it is affecting the health.

These, among other aspects of leadership, show the diverse influence of leadership in organisations. In the past few decades there has been a debate about not only (positive) leadership, but also destructive leadership. The only form of leadership that is undoubtedly positive is the one high in its direction towards both the organization and the employee. The prevalence of diverse kind of destructive leadership is great, and the most prominent is the absence of leadership (Aasland, Skogstad, Notelaers, Nielsen & Einarsen, 2010).

3. Job-Demands Resources model and leadership

The Job-Demands Resources model has been extensively studied the last decade (Schaufeli & Taris, 2014). It claims to integrate the earlier work stress models. The model states that there are two processes involved: One motivational process leading to perception of bad health and another leading to positive outcomes. Job demands of diverse kinds will lead to perception of strain. Prolonged strain leads to deteriorating health (Ursin & Eriksen, 2004). The other process is a motivational process where a diversity of resources in the work environment (support from colleagues and supervisors, innovative environment, good flow of information etc.) leads to engagement. Engagement mediates productive outcomes. These processes are linked: Job resources mediate burnout, and burnout influences engagement, productivity and health. There is also strong evidence of job-satisfaction having positive impact on health.

The simplest form of connecting leadership to outcomes is a direct link from leadership to health and productivity outcomes for employees. We find this kind of conceptualization in frequently in studies of leadership. The direct effect of leadership is moderate.

Most analyses of leadership include mediating and moderating variables. The effect of leadership (and other positive variables for employees) on productivity outcomes is mediated through work engagement and intrinsic motivation. In the organizational climate research these variables are supposed to influence workers' attitudes and motivation, and thereby outcomes. Following these conceptions of leadership and climate, Support from leader, Just leadership and Empowering leadership would be considered to be job resources/organizational climate. They thus would be expected to have significant contribution in both in the motivating process and as a moderator of strain. Figure 1 shows a modified JDR-model where leadership is explicitly modelled.

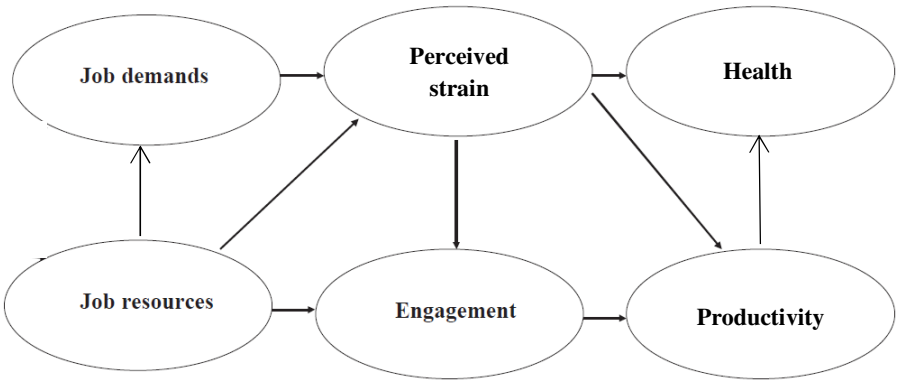

Figure 1. A modified Job-Demands Resources model

4. Methods

The survey was distributed by electronic means to 3.400 employees in a public organisation. The organizational climate survey consists of well-known scales of leadership, climate factors such as innovation, autonomy, intrinsic motivation and outcome variables like job satisfaction, stress and health. A confirmatory factor analysis was conducted for leadership indicators.

5. Results

The confirmatory factor analysis indicated that leadership is one construct consisting of three facets of leadership; supportive, just, and empowering leadership. Results from correlation analysis show moderate correlation of the leadership dimensions to many other variables. The exception is correlation to demand variables where leadership association is low to non-existent (,00 - ,17). The direct association of leadership to job satisfaction is relatively high (,41 - ,48) and low for effort (,04 –

0,17) and moderate to health (,18 -,21). All leadership factors are moderately negatively associated to quantitative job demands and low and not correlated to learning demands and not correlated to demands to decisions. Support from leader is the leadership style that has the strongest negative association to job demands, perception of stress, role conflict and positive association to perception of health and role clarity. Empowering leadership has the strongest association to job resources/other organizational factors.

6. Discussion

We included three indicators of leadership; supportive, just, and empowering leadership. According to Yukl (2012) these aspects of leadership all have in common their emphasis on relations with employees. Two other aspects of leadership related to the employees are not included (task and change oriented). The result in this analysis indicates that supportive, just and empowering leadership are different facets of relations-oriented leadership.

The direct impact of leadership on job satisfaction (,45) is higher than effort (,22). This indicates that the emotional side of leader-member relation is high. We expected that leadership would be strongly associated to all job demands, but leadership only had association to quantitative demands. We suppose the results reflects that the leader have greater impact on the quantity of job demands in this organization than learning demands and demands to decisions. It may be explained by the highly skilled workers (professionals with long education) with high degree of autonomy. For most of the leadership associations to other variables, their impact was approximately even. This strengthens the indications that these leadership scales are facets of a common social relation leadership factor.

7. Conclusion

The diverse influence of leadership in a lot of processes in the work environment is probably the reason why laissez faire leadership is so destructive – the absence of leadership leaves these important matters to chance and to the mercy of aspiring informal leaders among the employees chance. Including indicators of task and change oriented leadership behaviour in studies of leadership, productivity and stress probably will paint a more comprehensive picture of leadership in the stress process.

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Mobbing and conflict – On irrational critique and the ethics of intervening

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Abstract *The following outlines a new approach, to the research field of conflict and mobbing in workplaces. The established paradigm is challenged, mainly due to the ethical implications in defining a mobbing incident as aggression. The foundation for building a new hypothesis on the field is construed through a definition of a scientific approach, inspired by the collective works of Aristotle primarily as presented by Professor Ph.D. Bent Flyvbjerg (2009). In this qualitative formation of a new hypothesis the methodology is based on genealogy, critical theory and critical phenomenology as formulated by Mortensen (2013). The hypothesis presented in this paper is that a share of mobbing phenomena can be explained as irrational critique. This means that workers experience concealed pressure on their professional identity, which strains interpersonal interactions in work-life today forming conditions for conflict and mobbing.*

Keywords Ethical intervention; critique; professional identity; mobbing; historic materialism

1. Introduction

Exploring the field of mobbing in workplaces inspired me to form a new hypothesis. In order to define new ways of understanding the complex social phenomena, constituting mobbing in workplaces, it seemed necessary to define a new approach to the scientific methods for both theoretical and empirical exploration. My main source of inspiration is Bent Flyvbjerg (2009). In his work to make social science matter, Flyvbjerg (2009) highlights the need for a dynamic understanding of power to form a (phron)-ethic science that enables us to define positive and negative effects of our research in social sciences. Flyvbjerg (2009) combines Aristotle's phronesis with a postmodern concept of power derived from Foucault, which forms a unique understanding of the human conditions as historic materialism. Viewing social phenomena as historic and materialistic demands that societal structures, sociality and individual parameters are explored simultaneously (Daniels 2011; Edwards & Daniels 2012). The following is inspired by these approaches because of their potential for forming diverse and new approaches to the established paradigms of research in the field of conflict and mobbing at workplaces. The aim is to formulate a new hypothesis and outline a new research paradigm for the area of conflict and mobbing, as well as to point towards new directions of more ethical interventions, by enabling conflict and mobbing to be seen more directly as consequences of today's organisation of work. The perspectives on ethical interventions are elicited through the analysis and discussion of how sociality, identity and changed conditions for criticism in work life today, all form concealed conditions for the spectra of phenomena defined as conflicts and

mobbing at workplaces. Viewing conflict and mobbing as irrational critiques, allows us to understand more perspectives in a conflict simultaneously and intervene proactively instead of retrospectively, which allows for more ethical interventions to be formed.

In the established work with defining and researching on the diverse phenomena of mobbing, the theoretical formulation is built on a thesis of aggressive behaviour (Einarsen 1999; Leymann 1996; Schott 2009). In this perspective aggression is defined as an outcome of frustration (Berkowitz 1989; Dollard et al. 1980). This assumption relies on descriptions of internal psychological phenomena, and an interactional intervention seems hard to construe. Other studies suggest that mobbing can also be seen as a result of a variety of complex phenomena such as organizational development or cultural changes (Bailien et al. 2009; Hoel & Salin 2003; Skogstad et al. 2007). Therefore a new hypothesis, which can explain these findings as coherent, and form new and more ethical interventions, is the subject of this paper.

2. Concepts and methods

As mentioned in the beginning a primary source of inspiration for the following work was found in Flyvbjergs (2009) formulation of Aristotles *phronesis*. Phronesis names the obligation for a social science to calibrate its future impact on sociality through a consideration of ethical implications inherent in its research methods (Flyvbjerg 2009). It is best viewed as a third wheel on the scientific mill, where epistemé and techné form the other two. Epistemé and techné can be translated to the epistemological and technological traditions of science. These two form most of the field of natural sciences and are the idealized practices in almost all positivistic sciences – they are almost per definition the scientific methods (Flyvbjerg 2009). The argument Flyvbjerg (2009) raises against their main assumptions is the one of context. Like Aristotle, Flyvbjerg (2009) claims that contextual formations of social interactions and individual development cannot be understood within these two concepts of science. Therefore, the science of subjects and sociality needs to be performed in a different manner, than the science of objects. To take into account the contextual complexity of the social sciences, the practice of social sciences must also take into account their own position as a social enactment (Flyvbjerg 2009). To define and qualify social enactment and contextual value, Flyvbjerg (2009) introduces a concept of power, derived from Nietzsche and Foucault, to enable the social sciences to define their practice from (phron)-ethic standards.

In order to derive a dynamic concept of power regarding certain subjects of interest in social sciences, Foucault (1980), like Nietzsche formulates a methodology of genealogy. The genealogical method is concerned with the history of scientific concepts and their relations to other concepts formed in similar traditions – in short it is the kinship of scientific concepts, which reveals their cultural and discursive impact on our contemporary practice of science (Foucault 1980: 83). Structures and subjective enactments are equally important in forming and upholding discursive formations of power, but shouldn't be analysed without their historical context. From a historic materialistic offset the field of interest becomes predispositions and institutionalized practices, alongside the practice of the social science itself (Bertilsson 2000; Flyvbjerg 2009).

So in order to formulate a new hypothesis, part of this phron-ethic approach was to have a closer look on the historical practice in the research field on mobbing and conflict in work places. I therefore analysed the historical context and offset of key concepts in the research field. The concept of aggression seemed to be the most common and standing concept explaining the formation of mobbing in various social contexts from school life (Olweus 1980; Schott 2009) to adult professional work settings (Berkowitz 1989; Mikkelsen & Høgh, 2010; Einarsen 1999; Leyman 1990). When you follow the references you find that aggression is formulated as closely related to frustration. The biggest contribution in this tradition is the Dollard et al. group who formed a hypothetical basis for a scientific definition of aggression around 1939 (Berkowitz 1989). The concept of aggression which is carried on by Olweus (1980) and Berkowitz (1989) stems from an interpersonal understanding of human interactions

as conscious and rational and therefore determined by the conscious will of the people interacting. Aggression is defined from the position of the subject enacted upon – the victim of mobbing. The logic is that the aggressor aims at harming his victim. We therefore see that many interventions aim at changing the mindset of the people involved preferably through forming a mobbing policy (Mikkelsen & Høgh 2010; Schott 2009). This leaves an "open end" outcome scenario, where different scenes can play out and various risks have to be calculated. This, in many cases, leads to the preparation of sanctions that can be put in to effect, should mobbing occur (Hansen 2009; Mikkelsen & Høgh 2010). In short, the frustration-aggression hypothesis leads to a narrow field of interventions in which we must define local cultural norms to form a policy of mobbing, prepare sanctions to minimize risks of people acting in conflict with the policy, and sanction the unwanted behaviour (Hansen 2009; Schott 2009). The success of this intervention plan is defined by our ability to retrospectively define a *victim* and an *aggressor* (Schott 2009). If these two positions aren´t defined the above will be impossible to uphold. One problem, seen from an ethical point of view, is that naming the aggressor can lead to psychological strain for the person pointed out (Mikkelsen & Høgh 2010: 32).

Through a genealogical analysis, we see, not only the power enacted between the scientific research paradigm and the subject of interest, but also certain logics inherent in this scientific discourse (Foucault 1980). These logics will in turn empower certain positions in a conflict that can be characterized as mobbing. The scientific stance, in the aggression hypothesis, empowers the position of the "victim" (Schott 2009), but simultaneously shames the retrospectively defined position of the bully. The power of definition is, in this manner, handed the victim of bullying in a retrospective frame of intervention. This has several implications. One implication is that bullying often evolves from conflict and in many cases it is not possible to define a victim in the conflict as it is evolving (Schott 2009). Secondly it makes it very hard to explore the perspective of the bully, and the main source of information on what makes people bully is therefore victims of bullying (Bailien et al. 2009; Einarsen 1999). From a qualitative research perspective, this renders the theories of why mobbing occurs speculative and is in contradiction with the defined goal of phenomenological exploration of mobbing.

To reinstate a phenomenological practice in the research field, which includes the perspective of everyone involved in a conflict or mobbing, we can look to a *critical phenomenology* as suggested by John Mortensen (2013). The methodology described by John Mortensen (2013) is in close alignment with the theoretical cardinal points in the historic materialism. The focus is on exploring the informant's life-world but Mortensen's point is that the experienced life-world is a limited source of relevant knowledge of a subject in social science. He therefore seeks to reinstate the critical practice in phenomenology, which enables us to reveal concealed structures' influence on sociality and individuals by expanding and analysing the borders of the conscious life-world (Mortensen 2013). Different from other approaches to phenomenological practice, the interview into the subjects life-world is not interpreted free of the subjects cultural, historical and institutional structures – this includes the position of the researcher as well (Mortensen 2013).

3. Formation of a new hypothesis – Mobbing as irrational critique

As shown it can be argued that forming a hypothesis in a historic materialistic could widen the possibilities for forming new research methods. This however sets certain criteria for the research and theoretical considerations. Edwards and Daniels formulate the specific criteria for historic materialism this way: "The task is not an easy one: it calls for linking the agency of the practitioner with the motives of the practice while considering the implications for the institutions in which these practices are located." (Edwards & Daniels, 2012: 41). So in order to formulate a new hypothesis on mobbing, which takes into account both agency and motivated practice, the formulation of aggression and frustration, had to be reconsidered. They are formulated on an interpersonal level. Firstly the concept of frustration (Dollard et al. 1980; Berkowitz 1989) enables understanding of motivation but mainly in regards to the influence from an opposed subject and not institutionalized and structural influences. Secondly the

concept of aggression enables understanding of actions performed by an opposed subject and therefore excludes the possibility of viewing agency from the performing subject (Schott 2009).

To understand structural frustration the concept of complexity in communication derived from the works of Niklas Luhmann (1999; 2000) is suggested. In his works is a formulation of cultural communication across systems of human interaction. It also includes communication imbedded in institutions and structures surrounding different practices (Luhmann 1999; 2000). To align with research on work life in general, and to form a mediation of agency in subjects interacting, a concept of identity as historic materialistic is also suggested (Schwartz et al. 2011). It can be argued that Luhmanns formulation of self reflexivity is interchangeable with the concept of identity on the premise that subjective differentiation will lead to a concept of self (Mortensen 2013). I therefore formulate a concept of professional identity as dependent on both structural and interpersonal communication. Professional identity as a means of autopoesis is under pressure in modern work-life due to increased complexity and ever changing demands (Strangleman 2012; Hall & Mirvis 2013; Qvortrup 2001; Willig 2013).

To define agency in these conditions, Willig (2013) formulates a concept of critique. His definition of critique includes both structural influences and motivation for action from a subjective perspective. His thesis is that critique is hard to direct at structural sources of frustration due to increased complexity and egocentric concepts of performance. Therefore, he argues, we have a tendency to direct our criticism inwards. This distorts our self-understanding and diminishes our capability to act in accordance with our values (Willig 2013). In short it lessens the capability to utilize our professional identity in our work-life and therefore creates confusion and frustration.

If mobbing, and the research on mobbing, is put in this frame, a possibility to understand acts of "aggression" as acts of critique emerges. This enables us to understand and explore actions, not as aggressions with victims, but as motivated actions intended to counteract hidden structural frustrations. We have to start viewing these actions as irrational, in the sense that they are not necessarily directed at the source of frustration. If hidden structural communications challenges our sense of work identity on an increasing level of complexity, we can assume that the subjects who act are not always aware of these influences (Foucault 1980; Luhmann 2000; Willig 2013). The "aggressive" interpersonal actions can therefore be seen as a masked critique, which ought to be aimed at the organization of work and administration of tasks.

This perspective opens the possibility to include the perspective of a "bully" as a justified agent in future research. This will enable us to form more ethical interventions, where more positions can be taken into consideration at the same time, hopefully reducing the number of shamed and fired workers in the aftermath of mobbing incidents at a workplace.

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Ergonomics Risk Management in Ireland: An evolving process

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Abstract
There are three areas of workplace health and safety legislation in Ireland which address Ergonomics; the Safety, Health and Welfare at Work Act, the Manual Handling of Loads Regulation and the Display Screen Equipment Regulation. As a result of a court case related to ergonomics and manual handling practices, important precedents resulted which underlined the importance of risk management. Recent developments including the EU Council Recommendation 2013 on Ergonomics has shown that there is a clear movement toward a risk management ethos with the emphasis on introducing engineering interventions to minimise exposure to risk factors originated by poor ergonomic conditions.

Keywords:
Ergonomics, Risk Management, Engineering Interventions, Manual Handling

Introduction

Ergonomics is about the relationship between the worker and the work that they do and it focuses on the design of work areas or work tasks to improve job performance both in terms of health and productivity. It is important to keep this in mind as a reminder when considering strategies for Ergonomics at Workplace level. The Health and Safety Authority is the regulatory body in Ireland responsible for the enforcement of Occupational Safety, Health and Welfare at Work legislation. According to the most recent data available (Stats Report 2014) there are 1.913 million people at work in Ireland with an unemployment rate of 10%. The top five work sectors are manufacturing (239,000), wholesale and retail (272,400), Accommodation and Food Service activities (137,000), Education (149,000) and Health and Social Work Activities (247,200). In 2014 there were 7,431 non-fatal injuries reported to the Health and Safety Authority and injuries due to Manual Handling account for 32% of all reported non-fatal injuries.

Legislation

The main pieces of health and safety legislation in Ireland that relate to Ergonomics are the Safety, Health and Welfare at Work Act 2005, the Manual Handling of Loads Regulation 2007 and the Display Screen Equipment Regulation 2007. A significant proportion of injuries due to manual handling relate to lifting activity and the injured body part is predominantly the back. There is little occupational illness data available in Ireland as illnesses are currently not reported. A voluntary reporting system was set up a number of years ago and the data collected thus far identifies the main illness issues as musculoskeletal disorders and illness due to stress.

Manual Handling Training versus Ergonomics Risk Management

Historically in Ireland there was an over reliance on manual handling training (safe lifting technique) as the most appropriate intervention to address ergonomic risk (to include manual handling) in the workplace. Over the last fifteen years there have been significant interventions introduced to change the mind set to one where the main focus is on ergonomic risk prevention through effective policies, risk assessment, introduction of engineering interventions and training.

The Courts

However a significant development took place in 2003 when a court ruling resulting from enforcement action taken by the Health and Safety Authority related to contraventions under the Manual Handling of Load Regulation resulted in a successful outcome for the Authority. As a result of the court ruling the employer was directed to implement appropriate measures to reduce the risk of back injury through the introduction of mechanical handling equipment. This case was heard over two years in two different courts, however the most interesting aspect of the case was the court judgement that resulted after the final court hearing; the judgement was very much focussed on the nature of work carried out, the nature of the ergonomic risk factors at each stage of the task and the pros and cons of the proposed appropriate control measures. In essence the judgement was a very good example of ergonomic risk assessment and it formed the basis of planned future guidance in the area of Ergonomics.

New Ergonomic Strategy

A new Ergonomic strategy was developed to address musculoskeletal injury in the workplace and the main pillars of this strategy were, the development of sector specific guidance, the development of a competency based framework for manual handling training encompassing new learning outcome based standards for training programmes and new requirements for training providers, the development of evidence based research projects, introduction of a inspector training programme on how to address ergonomic issues during inspection, introduction of a new ergonomic inspection referral process and the set-up of a network with external professional bodies and agencies. Despite the introduction of these interventions, the non-fatal manual handling injury statistics have remained at a stubborn rate of 32% over a number of years.

The EU Council Musculoskeletal Disorder Directive

The Health and Safety Authority recognises that while the strategies that were introduced did have a positive impact, there is still a significant body of work to be done not only at the workplace level but also at a general policy level. The work completed by the EU Commission which resulted in a draft MSD directive and a 2013 Council recommendation on Ergonomics is a positive step in the right direction. The council recommendation has shown that there is recognition at EU level that there needs to be a movement away from dependence on the intervention of training to a more sensible prevention focused risk management ethos with an emphasis on introducing engineering and/or organisational interventions to minimise exposure to risk factors originated by poor ergonomic conditions. In other words the agenda needs to be about Ergonomics and the relationship between the worker and the work that they do with a focus on the design of work areas or work tasks to improve job performance both in terms of health and productivity.

The future

In 2013 the Health and Safety Authority published a new publication which advocates a six element Ergonomic Risk Management programme to address musculoskeletal disorders that result from poor ergonomic conditions in the workplace. The six elements include:

- Policy: A policy on the prevention and management of Musculoskeletal Disorders (MSDs) is a statement of intent from an organisation in which they acknowledge that they have a duty of prevent and manage MSDs and they outline the measures and resources that they will put in place.
- Risk assessment and safe system of work: Under our regulatory framework, an employer has a duty to conduct a risk assessment of work activities including those where there are poor ergonomic conditions. The risk assessment must be comprehensive and demonstrate that the ergonomic risk factors have been identified and the appropriate control measures including engineering or organisational controls have been put in place. These control measures should be documented in the form of a safe system of work plan.
- Training: Training programmes need to be designed to make workers aware of the risks associated with manual handling, use of display screen equipment (DSE) and work activities with increased risk of upper limb disorders. It is most effective when supported by risk management that provides for risk assessment and the introduction of control measures.
- Accident and near miss reporting and investigation: Efforts to manage accidents that result in a musculoskeletal injury should be effective in preventing reoccurrence. There should be timely investigation of accidents and corrective actions need to be identified and put in place.
- Injury Management: While the Health and Safety Authority does not have a specific remit for the management of injured employees in terms of retention, rehabilitation, and return to work, they do recognise that there are effective interventions that can be put in place to reduce lost time and absence from work as a result of an injury that occurred at work.
- Internal auditing: An internal audit structured process is useful for collecting independent information on the effectiveness of existing systems and controls that are in place for the prevention and management of Musculoskeletal disorders in the workplace.

This six element model was put together as a result of observations and issues identified during workplace visits over a number of years, however we recognise that the management of ergonomic risk at workplace level on its own will not address the whole spectrum of MSDs. In the last year the Irish Government has set up a new initiative called Healthy Ireland which is focussed on the improvement of lifestyle issues related to diet, exercise and general health and well-being. We plan to give input to this initiative as it relates to the workplace and we are currently developing our own strategy for the period 2016-2018 which will place more emphasis on the management of health risks in the workplace.

Conclusion

The future poses significant challenges including limited resources, recession, ageing workforce, lifestyle issues, the changing nature of work, however ergonomics and the application of ergonomic principles has a significant role to play in creating a positive work environment in terms of the physical and mental well- being of people at work as long as there continues to be a relationship between the human and work activity.

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The Impact of Trainer on Training Transferability

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This paper seeks the answer of: "The Impact of Trainer on Training Transferability". Since last two decades, the use of advance and immersive training simulators have became a common practice in various domains. With advancement in technology it is possible to conduct training without a trainer We currently know very little about the effects of training without a trainer. This research challenge was tested in an experiment to find the impact on the acquisition of skills of trainees with and without a trainer. To test this effect we used The Plant Simulator (Nazir & Manca, 2014). Findings indicate that persons trained with a trainer produce fewer errors and requires less help, while those trained in the augmented virtual reality simulator is more efficient and uses less time.

Keywords: Training, Trainer, Assessment, Simulator, Augmented Virtual Reality

1. Introduction

The impact of training on the profitability and safety of processes are shown both empirically and theoretically in various studies (Nazir *et al.*, 2015). It is now well known that investment in training enables the individuals, teams, organizations and industries to achieve their targets in more comprehensive manners (Naderpour, Nazir & Lu, 2015; Salas *et al*., 2006). Various questions, for instance training for hazards and safety (Baker *et al.*, 2006), training effectiveness, rate of return of training (Kluge, 2014, Kluge, Nazir, Manca, 2015), impact of training on team work (Salas *et al*., 2006) and the like, have been recently answered or at least under continuous investigations. New technological advancements have brought new challenges to the operators (Lützhöft & Lundh, 2009). The evolution and revolution of industrial processes have made the roles and goals of operators challenging and delicate at the same time. Therefore, digging deeper on the topics of operator training is an investment, which researchers are trying to make.

Complex socio-technical systems such as the chemical industry involve higher levels of automation, overload of information reaching the operators, safety critical scenarios, distant and different working environments of field and control room operators, and hazardous nature of processes (Nazir *et al.*, 2012; 2014). Various training methods are used to instil the operators with necessary skills to cope with demanding daily operations. The authors are interested in investigating the effectiveness of various training methods on the performance of operators.

Research Question. The aim of this experiment was to identify the effects of training without a trainer. To do this we conducted an experiment comparing traditional trainer-based training with a novel trainer-free training situation using a simulator.

2. Methods

An experiment was designed and conducted for a specific procedure of a polymerization plant, *i.e.* catalyst-injector switch, where the operator has to follow a sequence of actions in a precise and timely way. The procedure for catalyst injector switch involves a total of 29 actions (only first 9 actions were selected for this experiment). A successful catalyst switch can be ensured only by following accurately such a sequence. Any errors in following the sequence can result in triggering an abnormal situation that may lead to a significant impact on the process operation and to relevant economic losses. Failure of catalyst switch is enough to bring losses of millions of euros as it requires complex maintenance activities based on the shutdown of the plant (and following startup when the malfunction is fixed) with consequent production losses and need for production rescheduling. Therefore, other than analysing the effect of training methods in IVEs on the performance of operators, this study focuses the attention on the effectiveness of training procedures for catalyst injectors switch in the production of PP.

Two groups of participants (N = 24) were trained within an immersive environment. One group (call it human trainer group) was trained with the support and help of a trainer, where the trainer demonstrated all the actions to the trainees in the training phase (see Figure 1).

Augmented Virtual Reality (AVR) was used for the training of the second group (call it AVR group). The augmented feature in the immersive simulator enabled the trainee to follow a set of sequence of actions. We have devised the following methodology for automated training

- the valve that need to be operated is in yellow colour (see Figure 2)
- once the valve is operated (closed or opened) the colour will change to green (see Figure 3)
- at the same instant the valve that need to be operated right after the previous one will appear in yellow
- the above sequence will be followed for all the procedures

Figure 1 – Training session for human trainer group

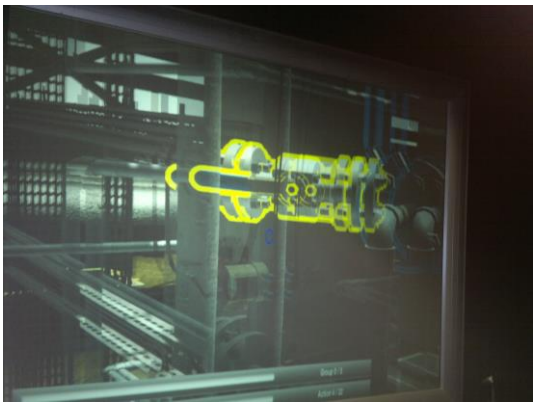

Figure 2 – Training session of augmented virtual reality group. The augmented yellow colour of the valve indicates that the valve shall be operated

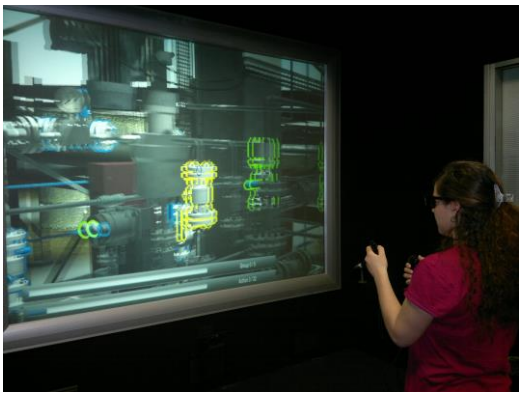

Figure 3 – A participant from AVR is in training phase

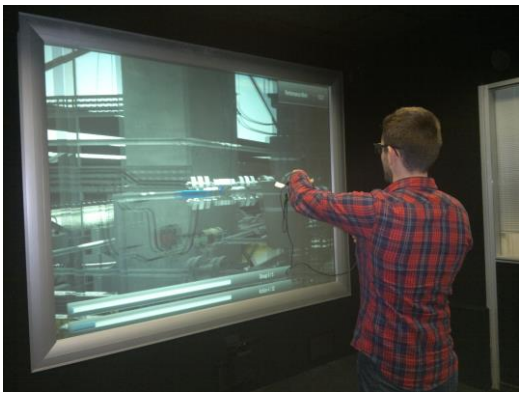

Figure 4 – A participant is conducting the final performance assessment after having gone through the training phase

Once the training phase is finished the participants are evaluated for the performance of the task. With reference to the catalyst injectors switch procedure, the performance assessment is based on the following dependent variables, which are named as Operator Performance Indicators.

Total Score: The total score obtained by the trainee. It is evaluated by a dedicated algorithm and is based on the number and nature of errors conducted and the number of helps requested.

Number of helps requested: If and when the help(s) was requested by participants during the course of experiment; they were recorded by the assessment software.

Number of errors: Each time the participant failed to perform the correct action the software registered it as an error.

Total time taken: As the name of this performance indicator suggests, it is the total time taken by participant to complete all the actions.

3. Results

Analyses of difference were done (for each of the performance indicator stated above) with the non-parametric Mann-Whitney U-test. The Probability of Superiority was used as an effect size measurement. The probability of superiority (*PS*; Ruscio & Gera, 2013) of is a measure indicating the probability that a randomly chosen value from one group is larger than a randomly chosen value from another group. If the groups were identical the *PS* would be 0.5 (giving a 50% chance that a value from Group A is bigger than a value from group B). If the confidence interval (*CI*) of *PS* does not contain .50 that means that we have a significant difference at $p = 1 - (CI / 100)$. Please see Grissom and Kim (2012) for information on how to calculate *PS* and *CI* for *PS*.

As can be seen from Table 1 there is a clear tendency that the trainer group did fewer errors and received a higher total score than the augmented reality group. The effect sizes were of medium and small size on Errors and total score respectively. The data also indicate that the Augmented reality-trained participants where faster than the Trainer-group and that they required less help. However, these differences were not significant.

Table 1: Comparison of the Trainer Group and the Augmented Reality-group

	Groups			
	Trainer	AVR		
Measurement	***M* (*SD*)**	***M* (*SD*)**	***p***	***PS* [95% *CI*]**
Errors	0.42 [0.9]	1.17 [1.03]	0.046*	.29 [.11, .48]
Time	400.8 [164.1]	322.6 [122.1]	0.326	.60 [.41, .84]
Help	0.5 [1.168]	1.58 [2.35]	0.092	.32 [.13, .52]
Total Score	87.1 [27.4]	65.1 [29.6]	0.031*	.75 [.54, .92]

Note: AVR = Augmented Virtual Reality, *M* = Means, *SD* = Standard Deviations, *p* = *p*-value for Mann-Whitney *U*-test, *PS* = Probability of Superiority, *CI* = Confidence interval. The table shows mean and standard deviations for the two groups. *p*-values are for the non-parametric Mann-Whitney U-test measuring the difference between the two groups. PS shows the exact probability that a randomly chosen value from the Trainer-group is bigger than the Augmented Reality-group. If the confidence interval contains .50 then the difference is not statistically significant.

4. Discussion

Evaluating the performance of operators in a dynamic, time dependent task is a challenge in itself. To overcome the same, an algorithm (Manca et al., 2014) was developed and validated which allowed a real time performance assessment of trainees while doing the catalyst-injector switch (a procedure which is performed bi-annually and where errors costs about millions of euros). The with trainer group showed higher accuracy, precision, identification skill and lower help requirements than those of AVR group. On the other hand the AVR trainer group showed better speed when compared with the former.

A possible explanation of this effect is that while the AVR group got more training in doing the actual movements, they did not get additional system information. On the other hand, the Trainer group would get more information about the system through the trainers presentation and hence they were more successful in creating a working mental model of the work task and the requirements. However, the trainer group did not get additional training on the performance of the movements. Nevertheless, there is a need of further experiments with similar research questions (possibly with more participants) that can increase the understanding of the role of trainer on overall training effectiveness.

5. Conclusion

The results show that the training lead by trainer produced more precise set of actions by trainee, whereas, training with augmented virtual reality resulted in higher efficiency in terms of response time. This study paves a way for further experiments and research in understanding the role and impact of trainer on the learning outcomes.

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Facilitators for the implementation of ergonomic interventions

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Ergonomic interventions have often been studied with focus on the client company in which the intervention has been implemented and not from the perspective of the Occupational Health Service (OHS) company providing the expertise knowledge. The aim of the study was to explore factors within OHS companies which facilitate ergonomic interventions. Semi-structured interviews with twelve ergonomists employed at eight different OHS-companies in Sweden, were performed. Five main facilitators were identified as important for ergonomic interventions; having close relationships with the client, clients' awareness of the wide-ranging competence of the ergonomist, utilization of standardized methods, specialization/industry knowledge and internal knowledge sharing.

Keywords: Occupational Health Services, Ergonomic interventions, Interviews, Qualitative analysis

1. Introduction

Studies evaluating ergonomic interventions aimed at reducing work-related musculoskeletal disorders (WRMSDs) have shown mixed results (Silverstein and Clark 2004). Several interventions have failed to reduce the occurrence of WRMSDs. Others, often those using a participatory approach with active involvement of the workers, have resulted in a substantial reduction of WRMSDs (Rivilis et al., 2008). Important facilitators for the implementation of participatory ergonomic interventions have been identified. These factors include support from management, supervisors and workers, sufficient resources (time, material, and personnel), ergonomic training, appropriate teams and communication (van Eerd et al., 2010). Furthermore, awareness and communication concerning health and safety issues, control over budget spending on health and safety measures, credibility, knowing the organization and key stakeholders, and the ability to align ergonomic interventions with business objectives are other examples of facilitators to succeed with ergonomic interventions (Shtivelband and Rosecrance 2011, Whysall et al., 2006). These factors have often been studied with focus on the client company in which the intervention has been implemented and not from the perspective of the OHS-company providing the expertise knowledge. Several earlier studies have explored the strategies for individual ergonomic consultants to navigate within the context of the client companies (Berlin 2011, Broberg and Hermund 2004, Ege 2006, Olsen 2012, Theberge and Neumann 2010, Whysall et al., 2004). However, the context in which the ergonomist operates differs between countries and the processes supporting the ergonomic interventions only partially takes place at the client company. An important prerequisite is the competence and experience of the ergonomist and the OHS-company (Querelle and Thibault 2007). The intervention is planned and organized outside the client company (Querelle and Thibault 2007) and thorough preparations are likely of importance for successful interventions. In Sweden, ergonomists are commonly employed by an OHS-company. Consequently, the organization and management of the OHS-companies creates the preconditions, which are likely to affect the work of the ergonomist.

However, little is known about underlying contextual factors within the OHS-companies that may be of importance for a successful implementation of an ergonomic intervention. Increased knowledge within this area may develop and improve the OHS-companies internal work strategies with ergonomic interventions. Hence, the aim of the present study was to explore and to reach a deeper understanding about factors within the OHS-companies which facilitate ergonomic interventions from a Swedish context.

2. Method

Semi-structured interviews with twelve experienced Swedish ergonomists (nine women and three men) were performed during the spring of 2012. The average length of work experience within the OHS sector was 15 years (range 4-25 years). The ergonomists were selected on basis of geographical spread and represented eight different OHS-companies in Sweden. Nine of the interviewees were employed in privately owned OHS-companies. These companies provided services to a wide variety of clients within different work sectors ranging from the service sector to heavy industry. The remaining three interviewees were employed as in-house ergonomists within one global manufacturing industrial company.

The interviews were focused on identifying facilitating factors affecting ergonomic interventions and the interviews followed an interview guide. The respondents were asked to describe and exemplify their involvement in ergonomic interventions which they themselves considered as successful. The interviews lasted 45-60 minutes. Due of the geographical spread, a majority of the interviews were conducted as telephone-interviews. The interviews were recorded and fully transcribed by the authors.

Qualitative content analysis was used to analyse the interviews, which were read through several times. Thematic analysis was applied; patterns were identified and classified into different themes (Kvale and Brinkmann 2009).

3. Results

In order to facilitate ergonomic interventions, from the perspective of OHS-companies, five themes emerged, which are presented below. The results are presented as quotes from the interviewees to exemplify findings and are freely translated from Swedish to English by the authors.

3.1. Facilitators

Close relationships with the client companies was considered important. This included both geographical closeness, so that assignments and on-site visits could be made easily, and frequent contact with the different stakeholders at the client company. The respondents reported that close relationship created credibility, which meant that the ergonomist did not have to argue to implement their suggested measures. "*Of course, it is a huge positive gain that I`m close to the management, or close to the department, because this means that I create better and closer relationships and solve problems faster, problems reach me quicker and I can quickly help change them." (In-house ergonomist).*

In-house ergonomists described that the company representatives, for example engineers or production managers, were able to directly access the ergonomist's internet calendar to make appointments. In other words, the internal IT-structure enabled close cooperation.

Clients' awareness of the wide-ranging competence of the ergonomist was in some cases seen as a precondition for the ergonomist to get assignments with a client company. However, in most cases the client was unaware of the ergonomist's competence within the domain of proactive ergonomics. Usually, the ergonomist was contacted after the identification of MSDs among the personnel. *"..it is only after the client became aware of that something will cause ergonomic problems…that they contact us. We would like to be seen as a resource, to be involved at the planning stage or refurbishment to prevent ergonomic mistakes, but problems are built in… It is hard…" (Ergonomist in private OHS-company).*

Utilization of standardized methods. Ergonomic interventions are usually preceded by an assessment of the work environment and the ergonomic assessments and analyses were facilitated by the utilization of standardized methods. It was customary among all the interviewees to use photographs or films during assignments to visualize the work situations when communicating with employees and management. However, among the interviewed ergonomists only those working as in-house ergonomists stated that they felt active support and encouragement by the management of the OHS-company to utilize standardized methods. *"…in our organization we have ergonomists that are coaching us other ergonomists, "competence manager", their role is as "strategic intelligence" and to provide us with information about ergonomics news and things we need." (In-house ergonomist).*

Specialization/industry knowledge. The interviews indicated that specialization and competence concerning the specific industry facilitated an intervention. To be able to work with solely one or a few client companies meant that the ergonomist was able to spend much time at the client company, something which contributed to deeper knowledge about the work environment and the organization of the client company.*"Since I been working internally within those companies I have developed a competence about their specific MSD risks and I can tell them what to do."(Ergonomist in private OHS-company).*

Internal knowledge sharing. Exchange of knowledge regarding interventions was a way to disseminate knowledge and to learn from each other within the OHS-company. This could for example result in shared document templates. This type of internal support routines were seen as supportive and simplified the ergonomist work tasks. One ergonomist described the involvement in developing a checklist regarding forklift trucks intended for spread within the company. *"We upload it on our internal webpage, ergonomic advice regarding forklifts…this gives feedback, we take advantage of the experience…"(In-house ergonomist).*

4. Discussion

This study identified five areas related to the context of OHS-companies in Sweden as important to facilitate ergonomic interventions. The two first areas identified; "*close relationships"* and "*clients' awareness of the wide-ranging competence of the ergonomist"* are factors that not are exclusively connected to the OHS-companies, they also involve the client companies. These factors require long-term relationships between the OHS-company and the client in order to develop the cooperation and to be able to market the different competencies of the OHS-company. Shtivelband and Rosecrance (2010) identified for instance that establishing credibility, to know the organization and the key stakeholders and to align the proposed intervention with business objectives were important principles for ergonomists to gain buy-in at clients. In order to create sustainable relationships with clients and to achieve buy-in one option for the OHS-companies is to develop and refine the contracts regulating their business relationship (Paulsson et al., 2014). Contracts lasting over several years can both provide conditions to create a close relationship with clients and enable marketing of ergonomic and other OHS services.

Studies indicate there is a lack in knowledge among stakeholders about what ergonomists can do (Berlin et al., 2014, Shtivelband and Rosecrance 2011, Whysall et al., 2006). This was also a barrier that emerged in our interviews. Furthermore, in accordance with Whysall et al. (2006) the present study identified that awareness about the wide-ranging competence of the ergonomist can facilitate the buy-in of ergonomic services. In addition, this awareness can also effect the prioritization of human factors and ergonomics at the client company (Berlin et al., 2014). In general, company managers associate ergonomics with mainly health issues (Jenkins and Rickards 2001). However, the field of ergonomics encompasses more than just health issues. Ergonomics also includes system performance, resulting in that ergonomists need to be searching for solutions in both the technical and the organizational domain (Dul and Neumann 2009). To influence "*clients' awareness of the wide-ranging competence of the ergonomist",* information and marketing about ergonomic are key issues. In a Swedish context, "Sales managers" or "Client managers" employed in OHS-companies are usually the ones responsible

for contacting clients and to make appointments and organize meetings. This means that they have an important role regarding information and marketing of the competence of the OHS-company. It ought to be in the interest of the OHS-company to see to that the "sales manager" or "client manager" is updated concerning the competence of the employees in the OHS-company and enable this information to reach current, as well as potential, client companies. As support to succeed with this is it of importance that the OHS-company develops internal structures regarding knowledge sharing. This study indicates that, facilitation of "*Internal knowledge sharing"* could be done through devoting time at workplace meetings to inform colleagues about specific project but also through internal web-based information.

Cantley et al. (2014) reported that systematic standardized methods can facilitate a reduction of MSDs. Therefore, it is important to support the "*Utilization of standardized methods".* It emerged in the interviews that having a "Competence manager" can be an organizational possibility for OHS-companies which may facilitate the "*Utilization of standardized methods".* The "Competence manager" provides the different OHS professionals with strategic intelligence and support when it comes to the utilization of different tools and methods, but also for the evaluation of the work. Since consulting require high chargeability it is difficult for practitioners to allocate time for competence development, an organizational solution with "competence manager" could therefore be beneficial both for development of the individual competence but also secure quality of performed assignments.

The principle "know the organization and key stakeholders" mentioned by Shtivelband and Rosecrance (2010), can be linked to the area "*Specialization/industry knowledge"* in the present study. An increased specialization (*"Specialization/industry knowledge")* within different areas (e.g. visual ergonomic, physical ergonomics, cognitive ergonomics, and organizational ergonomics) can be a viable strategy for the OHS-companies to provide more specific ergonomic knowledge to their clients. It would mean a professionalization of OHS-companies to distribute assignments to the consultants based at their specialization.

4.1. Methodological considerations

Themes emerging in a qualitative content analysis are intended to answer to the question *how* (Graneheim and Lundman 2004). The aim of the present study was to get a deeper understanding *how* ergonomic interventions can be facilitated through factors associated with the context of OHS-companies. Hence, a qualitative approach and content analysis was considered an appropriate choice of method. Even though generalizability is generally limited in qualitative research and the present study is based on a limited number of interviews, the results are indicative as to what areas OHS-companies in a Swedish context should explore in order to improve the success rate in assignments regarding ergonomic interventions (Table 1).

Table 1. Key findings and suggestions for the OHS. (The suggestions below are mainly based on the study interviews and following references: Berlin et al., (2014), Paulsson et al., (2014), Shtivelband and Rosecrance (2011), Whysall et al., (2004)).

Facilitating factor	Improvement suggestions for the OHS
Close relationship with the clients	• Development of contracts • Regular contact with stakeholders at client
Clients' awareness of the wide-ranging competence of the ergonomist	• Marketing • Information to clients • Relate interventions to economic benefits for clients • Case-studies
Utilization of standardized methods	• Competence manager who support education and implementation in methods. • Evaluation of work
Specialization/industry knowledge	• Branch specialization or occupational specialization • Distribution of assignments to consultants based at their specialization
Internal knowledge sharing	• Internal structure and system to take care of and to spread information within the OHS-organization.

5. Conclusions

Within a Swedish context, the organization and competence of the OHS-company can have an important impact on the possibilities for the ergonomist to work successfully with the client company. Important facilitators for the implementation of ergonomic interventions, identified in this study were; close relationship with the clients, clients' awareness of the wide-ranging competence of the ergonomist, utilization of standardized methods, specialization/industry knowledge and internal knowledge sharing.

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Organizational aspects of work load and health among occupational groups in a Swedish public sector dentistry

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1. Introduction

A high proportion of older people in the population tend to retain their own teeth thus requiring ongoing dental care as they age. However, the number of dentists graduating is expected to decrease until year 2023 (Socialstyrelsen 2009). Swedish County Councils have implemented changes in the provision of dental health to ensure they are able to meet the oral health needs of the community. This approach involves delegation of tasks to dental nurses and additionally creating division of responsibilities between dental hygienists and dentists. These changes in professional roles may impose different and new physical and psychosocial work demands which may negatively impact on their work ability creating the potential for ill health and sickness absence (Bejerot *et al.* 1999, Jonker *et al.* 2011, Westgaard and Winkel 2011) which in turn is counterproductive due to the cost of sickness absence to society and employers (Persson *et al.* 2014).

2. Objectives

To understand the impact of such task reorganization, this study aimed to evaluate the health of workers in workplaces with more or equal number of dental hygienists to dentists (Group 1) with workplaces that have more dentists then dental hygienists (Group 2). Differences in proportions between these groups in terms of perceived physical and psychosocial workload, leadership, perceived exhaustion, employees with musculoskeletal disorders, psychosomatic disorders, work ability and reported sickness absence and presence were investigated.

3. Methods

The study design was a cross-sectional quantitative study. All 486 employees in the Public Dental Service in a Sweden County Council were invited to respond to a web-based survey with questions concerning perceived physical and psychosocial work load (21 items), Physical exertion (14 items) musculoskeletal and psychosomatic disorders (13 items), leadership (3 items) and work ability (3 items) and sickness presence and absence (4 items). Data were analyzed with Chi^2, Correspondence analysis, Spearman Correlation for Chi^2 and Binary Logistic regression analysis using SPSS version 22 (IBM Corp, Armonk, New York, USA). This research was approved by the Regional Ethical Review Board in Linköping (ref. no: 2012/186-31).

4. Results

There were 321 employees who returned the questionnaire of which 39 employees were excluded. The final study group consisted of 282 employees. The psychosocial work environment was different for all three occupational groups (dentists, dental nurses, and dental hygienists) between Group 1 and Group 2. A significantly ($p<0.05$) larger proportion of dentists (93%) and dental hygienists (93%) and dental nurses (66%) in Group 1 reported poor psychosocial demands than those in Group 2 (69% / 65% / 47%). The largest and most common differences between Group 1 and Group 2 were reported by dentists who also reported greater exertion after work (Group 1=48% / Group 2=25%), sickness absence due to physical workload (19% / 2%), disorders of the hip (30% / 12%), sickness presence due to psychosocial workload (19% / 6%), sleep problems (30% / 10%) and were less satisfied with their job and work environment (56% / 17%). Dental nurses reporting poorer work ability in relation to psychosocial demands (62% / 45%). For dental hygienists, the pattern was mixed with a higher proportion of disorders in the shoulders (53% / 85%) and elbows (0% / 35%). Generally, the data showed that dentists, dental hygienists and to some extent also for dental nurses, work was physically and mentally exhausting.

5. Discussion

That fact that all three professional categories, particularly in Group 1 report poor psychosocial demands to some degree suggests there are factors within the work environment where these jobs tend to place employees at greater risk of ill-health. Further, dentists in Group 1 report sleep disorders which may increase the risk of poor recovery from illness thus are exposing them to further health problems. In addition to this involves dental work in general very fixed postures with unbalanced and repetitive tasks especially for dentists and dental hygienists regardless of group affiliation. By placing the health of oral health workers at risk may ultimately affect dental production negatively. However, the presence of a health problem is a strong determinant of sickness presence, especially for professionals who are difficult to replace.

6. Conclusion

Perceived poor psychosocial work environment increase the risk of sickness presence at work and thereby the potential for reduced productivity at work. Dentists in workplaces with an equal or greater proportion of dental hygienists than dentists report poorer mental work capacity and less job satisfaction. Dentists, compared with other oral health professionals reported higher sickness presence due to both physical and mental stress and sick leave due to physical stress. Workplaces with more or equal number of dental hygienists as dental nurses are also consistently smaller workplaces with usually fewer than ten employees, compared to workplaces with more dentists, where there are usually more than 20 employees. It is possible that a redistribution of the number of dentists to dental hygienists may not be the only solution to meet the future demands within oral health service sector especially if it comes at the expense of the health of the dental professional.

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Design features of an office chair promoting health and performance upon sedentary work

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Extended abstract:
Today there is a large amount of knowledge about appropriate ergonomics postures upon sedentary work. The market offers a large selection of office chairs with numerous possibilities of adjustments for wide-ranged sitting postures. However, it is often difficult for the users to understand how the various settings should be adjusted to achieve the best individual postures at different occasions. Too many settings, with altered designs and functionality can be confusing.

Sometimes problems do occur when an office chair has many options for adjustment. Various controls, such as buttons, knobs and levers can be difficult to understand for the users. This applies to both the purpose of the controls and how they should be handled. It is often difficult to know, without instructions and help, how an optimal setting should be chosen for a single individual. Therefore, instructions, both written and oral, and also an introduction given by an ergonomist/physiotherapist are very important in the concept of how an ergonomic office chair should be fully utilized.

The objective of this study was to find out how different adjustments of an office chair were perceived, interpreted and used during sedentary work. Well-being, in terms of physical comfort, health effects and working performance was also studied during a longer period of work and related to design features of the chair.

In total 48 full-time employed office computer workers in two companies in Gothenburg participated in the study. Over a five week period, they changed their existing office chair to the RH Logic 400 chair. This chair has a number of controls (with graphical information) for individual adjustments resulting in a variety of possible sitting postures. Each week the participants filled in an questionnaire with estimations of their experiences of how the chair influenced their work. Among the 48 participants, 28 received an oral introduction with training about ergonomic features of the chair.

The results showed that the understanding increased significantly ($p<0.01$) regarding how to adjust the chair when oral introduction/training was given. Also adjustments were significantly ($p<0.05$) used more frequently in this group, especially the tilting function. In general this group adjusted their chair 2-3 times per day the first week, while the other group adjusted their chair only 2-3 times during the week. However, when comfortable settings were found the users seldom adjusted the chair again. The number of adjustments decreased after two weeks also for the group who got

introductory training.. Sitting height was most often adjusted, followed by seat back angulation. The positions of the neck support and armrests were seldom changed. Few users understood that the length of the seat cushion was changeable.

The physical comfort of the chair was generally considered to be at least as good as, or better than in their previous office chairs ($p<0.05$). A comfort increase of 20 % was experienced by half of the participants while a third graded comfort increase of at least 30%.

Half of the participants felt that the physical strain in the neck and shoulders decreased after a few weeks of work in the chair. The chair was the only product that was introduced in their working enviroment, they did not change table hight, hight of screen or mouse location differently than before. After 5 weeks, the perceived load was reduced by 20-25% for the neck and 10-15% for the shoulders ($p<0.05$). One third of the participants also felt that the load in the lower back decreased during the period. Especially, discomfort in the right part of the body was reduced. The participants who had reported long-term problems in the neck and shoulder regions before the study felt that their symptoms were reduced by 30-40% ($p<0.05$).

To sit in the chair during computer work was estimated by the majority of the participants as beneficial for achieving a good working technique ($p<0.05$). More that 70% of the participants considered that the RH chair affected the complete working situation positively. Almost 75 % of the participants also felt that their working technique was improved . One third also experienced that their performance increased and the time pressure decreased.

To conclude, this study has shown that design features of an office chair can promote well-beeing if used properly. It is important that users understand how the controls should be used to support the body's natural sitting behaviour and that the chair should be adjusted several times a day. To use a variety of sitting positions during a working day results in that the muscles relax and thereby the risk for physical problems. In order to move the body also during sitting working conditions, it is highly recommended to use the tilting function of the chair frequently.

When delivering office chairs it is important to introduce people on how to use the design features of the chair to accomplish appropriate sitting postures that promote health and performance. Relevant written information material is also needed, explaining how good individual sitting postures can be found by adjusting the settings in a correct order of priority.

Movement in Mind – exploring bodily approaches in office work

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Workers from many professions have seen their physically labour-intensive work transformed to machine-assisted office work. This transformation has to some extent recently been related to information technology IT. Although IT is mainly mobile and we may have put the office in our pocket and left the building—we are often sedentary. Being sedentary is a health risk. In this paper we discuss how design of IT seems not to fully have considered our needs for physical activity. Reviewing literature including HCI, IxD and HF&Erg related papers we conclude that designing for integration of physical activity with work tasks may be a way to invite the body back to work.

Keywords: Physical activity, Interaction Design, work environment, Human work

1. Introduction

There has been a shift, a transformation in workload towards a less physically active and more sedentary work style for many occupations and professions. Church et al. (2011) have studied the situation in the US. Their results show a progressive decrease in the percentage of people engaged in intensive physical activity during their workday (Church et al., 2011).

The shift towards living increasingly sedentary lives in recent decades throughout the world is partly related to technology development and work-organizational development focusing on efficiency and safety (Cavill et al., 2006 and Craig et al., 2012).

When computer technology entered our workplaces and other areas of our everyday life, many of the opportunities to use our physical abilities diminished. The shape, size and form of computing technology have influenced and placed limits on the physical movements that are possible to perform during the human-computer interaction situation. The macro-monotony of large movements in, for example line production, has become the micro-monotony of small movements in computer-based work tasks.

Office work done in many different professions is often performed through interaction with computer technology. A person sitting in front of a computer doing office work expends insignificantly more energy than someone lying flat in a bed (Ainsworth et al., 2000 and 2011). From an occupational health perspective, many daily hours seated leave us without adequate physical stimulation of our muscles and cardiovascular system (Thorp et al., 2011). Although engineers have developed technology such as laptops, tablets and smartphones that let us get off the chair and leave the office, we seem to nevertheless be seated.

Hallal et al. (2012) argue for a translation of knowledge into action, and they have found that people living in the 21st century are experiencing societal trends of decreasing levels of physical activity and that approaches to date have not been able to change this situation. They state, *'The traditional public health approach based on evidence and exhortation has – to some extent – been unsuccessful so far. With few exceptions, health professionals have been unable to mobilize governments and populations to take physical inactivity sufficiently seriously as a public health issue'* (Hallal et al., 2012, p.254).

This is in line with our initial reflections from previous studies into the area of physical activity in the workplace and local transport (Tobiasson et al., 2012 and Tobiasson et al., 2014). There are many initiatives that seem to separate physical activity from daily activities such as work, local transport, domestic activities and mainly approach physical activity as a specific activity with the main focus and purpose of just being physically active.

2. Objectives

The purpose of this paper is to discuss the paradox between the transformation of work from physically demanding work to lighter knowledge work, the human body's need for physical activity to sustain function and stay healthy and design of mobile technology to enhance physical activity. A design-space is described where more research is needed.

3. Methods

The research presented here is a selection of what we, when reviewing the literature on the related topic, perceive as most relevant. The search for publications has been performed from ACM and Affiliated Organizations and HFES among others. Timespan was set mainly from year 2000-2014.

The search of literature was done using a mix of keywords such as 'physical activity' 'interaction design' and 'office workplace'. Applying what could be defined as a first version of a content analysis (Krippendorff, 2012) the material was examined and analysed. The many bits and pieces when put side by side and in relation to each other made a picture unfold. We define this picture as a design-space-an area for further explorations and research.

4. Results

We found that perspectives on physical activity are often discussed and studied in relation to different health parameters (Bellardini & Tonkonogi, 2013; Korhonen, 2010; Healy et al., 2011; Van der Ploeg et al., 2012; Parry & Straker, 2013 and Ekblom-Bak, 2013). This might seem to be a straightforward approach if aiming to present evidence that low levels of physical activity and prolonged sedentary activity are creating health problems.

To date, many of the attempts to remedy inactivity in office environments have been focused on products such as furniture, office layout, architecture, organisational issues (such as providing time for physical activity) and not the actual work task.

Many perspectives on body movements have been and are still emerging within the domains of Human-computer interaction HCI and Interaction Design IxD. Among others, research fields such as Physical Computing, Tangible Interaction are helping to pen up for physical movement while interacting with computer technology. A broad variety of products, apps and systems are available on the market to monitor and motivate individuals to be more physically active in their daily lives. Some examples of such products are FitBit, Jawbone, (Stackpool, 2013), LUMOback (Rosenberger et al., 2014) and iPosture (Bos and Cuddy, 2013).

Fitbit and Jawbone are worn as bracelets. They monitor movements and sleep patterns. LUMOback is worn around the hip and monitors posture. iPosture is a button that can be attached on the body to monitor change in posture; it vibrates when you slouch. The aim is to alert you to maintain good posture while sitting (Van Der Linden et al., 2011).

In the domain of Tangible Interaction, researchers such as Fernaeus et al. (2008), for example, discuss how pulling, squeezing and shaking can become computationally manifested.

The French philosopher Bruno Latour states that design is now mostly written code when it comes to the IT systems and computer products we use (Latour, 2008). He discusses how,

> 'Today everyone with an iPhone knows that it would be absurd to distinguish what has been designed from what has been planned, calculated, arrayed, arranged, packed, packaged, defined, projected, tinkered, written down in code, disposed of and so on. From now on, "to design" could mean equally any or all of those verbs.'(Latour, 2008 p.2) 'The transformation of objects into signs has been greatly accelerated by the spread of computers. It is obvious that digitalization has done a lot to expand semiotics to the core of objectivity; when almost every feature of digitalized artefacts is "written down" in code and software, it is no wonder that hermeneutics have seeped deeper and deeper into the very definition of materiality….Although the old dichotomy between function and form could be vaguely maintained for a hammer, a

> locomotive or a chair, it is ridiculous when applied to a mobile phone. Where would you draw the line between form and function?'(Latour, 2008 p.4)

The transformation of things into their digitalized representations also influences the opportunity for physical activity in the micro perspective of everyday actions. Continuing the form and function discussion, it seems as though digitalized products tend to decrease in size and become thinner and thinner, leaving us from a workload perspective, empty-handed.

5. Discussion/conclusions

Technology development has greatly lightened our physical burden in the workplaces and in many other areas of daily activities. The tricky part, however, is that if we design technology that takes away most of our opportunities in daily interaction that require some muscle force, we might experience health-related trouble, as we do need to put some degree of load on our skeletons, discs and muscles in order for them to sustain good function. Levels of physical activity or movement will also affect our alertness and awareness. Although we are capable of a broad variety of work postures, we seem to in many situations be left with micro-monotony. Monitoring products as exemplified earlier in this paper do not, as such, provide means for being physically active and less sedentary in the office environment.

The results from research within the health domain are clear in describing the negative effects and the risks following low levels of physical activity, but the results does not seem to trigger actions for a sustainable change. If physical activity is to become an integrated part of everyday actions to a greater extent than is present today in many settings, it might be of value to make use of these results as background knowledge, and rediscover physical activity or physical movement as a central component for the design of physical activity integrated into the complexity of real-life situations. We propose approaching the area of inquiry from a *movement-participatory design* perspective and start to develop more conceptual designs when aiming at rethinking and redesigning office workload. To work more in a cross-disciplinary fashion between explorative design-oriented approaches together with Human Factors and Ergonomics and health-related domains such as public health and preventive health seems a good starting point.

We articulate that there are still bodies around to attend to and to design for from an integrated perspective of physical activity and using the expression of Latour they are not likely to transform into written code.

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Voice ergonomics – an area for collaboration between speech language pathologists, ergonomics practitioners, and acousticians

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1. Background

A revised version of the Swedish provision regarding physical loads was released in 2012 by the Swedish Work Environment Authority (AFS 2012:2). One of the new issues addressed was the load on the voice and the vocal folds. AFS 2012:2 states that it is the employer's responsibility to ensure that the load on the vocal folds at work do not constitute a risk for voice disorders or injuries.

Voice disorders are treated clinically by speech language pathologists but this profession has little experience of field work in the work place. Ergonomics practitioners, on the other hand, are well experienced regarding supervision and problem solving at the work place but have little knowledge about voice disorders and voice ergonomics, causal connections and possible voice problem solutions. A voice problem may be caused by personal factors, a poor physical work environment or by a combination of those. Risk factors in the work environment are, e.g., poor air quality, poor room acoustics, and high levels of background or activity noise. Therefore acousticians should also be involved in problem solving.

Considering this background, the authors of this abstract have initiated several activities in Sweden to stimulate cooperation between involved professions with the aim to increase knowledge on these issues.

2. Goals

The goals of these activities are:

* to introduce suitable parts regarding voice ergonomics in the curricula for the basic education of the involved professions

* to create suitable literature and practical manuals for the involved professions

* to facilitate contacts between the professions by publishing contact lists of local experts over the country

3. Results

These activities have just started and have, so far, resulted in a contact list, published on the EHSS home page, over speech language pathologists with knowledge in voice ergonomics to be used by ergonomics practitioners for consultancies regarding work related voice problems. Much work remains to be done and hopefully more progress can be reported in the future.

How can future patient safety and work environment at expedition with advanced medical equipment be noted as important factors during the design and procurement phase in the perspective of an earlier serious accident?

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Eklund (2003) proposed a framework for interactions human, technology, organization (HTO) and environment, with work activities (HWA) shaping organizations' processes. Healthcare professionals work situation were investigated after death (SHK), RO 2013:02). HTO model will be used in intensive care with focus on future patient safety and work environment in the perspective of the accident. Interviews, study of routines and questionnaires will be thematized against the theoretical model. Several flaws were found after the accident and all can be thematized in the model although using the model is easier for HWA than teams.

Keywords: HTO-model, patient safety, work environment, design and procurement, cognition.

1. Introduction

HTO framework (humans, technology and organization). Eklund (2003) proposed an extended framework for interactions between human, technology, organization and environment, with work activities shaping organizations' processes to guide analysis of work activities, work systems and organizations in areas as safety, health, well-being and systems' performance with goals of improvement.

Procurement routines are found in management systems, (operations). Monitoring by medical equipment can be divided into work activities, which can be facilitated by technology, organization, environment and context. At the procurement stage, part of the design of future operations is determined. Procurement (and planning) is also affected by business practices and regulations, affecting future work environment. The HTO-models structure, with extensions to environment and context, make it a suitable model for analysing the procurement process.

Procurement within high-tech risk sites - nuclear power. The study (Jakobsson, Svenson & Salo, 2010) identified important steps in the process for inspection and self-regulation in procurement (including design and projecting) of high security rated zones in nuclear power. The identified steps will in the current study be used as a tool, combined with HTO-model.

Patient Safety. Healthcare professionals working situations and incidents were

investigated after one patient's death during post-caring observation after a heart surgery in an intensive care unit (Swedish Accident Investigation Authority (SHK), RO 2013:02). Mistakes occurred that happened in earlier patient care in connection with monitoring. Mental stress due to unclear procedures and high workload caused lack of patient safety and premises design was poorly positioned. These factors reduced the staff's ability to work patient safely. Swedish National Board of Health and Welfare has also conducted briefings in patient safety (Alvin, Loaf & Sop, 2014).

Work Environment. Architects drawings are of great importance when planning before construction and must take into account ergonomics and workplace aspects, so that healthcare staff can work safe. Design of work environment has implications for organizational and mental circumstances at workplaces (The Work Environment Act (Arbetsmiljölagen) (SFS 1977: 1160)) §2. Combination of physical environment, placement of technical equipment, teamwork and treatment of patients are potential stressors. It can give effects such as reduced cognition, performance and discomfort. Work conditions are regulated in different provisions.

2. Objectives

HTO model combined with the step model will be used as analytical tool for planning, designing and procurement in security-intensive care with focus on future patient safety and work environment in the perspective of an earlier death accident.

The practice innovation is to, by the HTO-model (Eklund, 2003) and the identified important steps (Jakobsson, Svenson & Salo, 2010) examine the planning, design and procurement process concerning premises for advanced medical equipment and is expected to provide suggestions for improvement in future patient safety, work environment, and systems performance.

3. Methods

Approximately ten interviewees who are part of a project team for planning, design and procurement will be examined by semi-structured interviews. Questionnaires will be distributed to about 30 affected employees affected. Written instructions will be thematized against the theoretical models. All answers from interviews and questionnaires are written down and integrated in the models.

4. Preliminary Results

We will now present some results of earlier experiences categorized with help of the HTO-model (in progress). The results will be from the analysis of the SHK report (the patient accident case) by the HTO-model. We will illustrate the results by giving descriptions of one or a couple of example/s from each category in the HTO-model: Operations, Main processes, Processes, Sub processes and Human Work Activity in interaction with environment, Technique, Organization and Context. Documents of the new facility's design are not yet analysed, neither is interviews conducted or questionnaires and is therefore left out of this paper.

Operation – The hospital level- Health Care, research and education. We have identified three areas for Operation level: health care, research and education. The health care section is in focus, more specifically the patient safety and work environment. The report SHK (2013) shows that a lot of documents which tell how the hospitals leading management should operate for reaching high patient safety, quality and effective risk assessments was found.

Examples of Patient-related documents that was found: "Strategy for patient safety…" – five steps for safer health care, and management and follow up instructions in various manager positions to develop an organization with high accuracy. Also there was found "Quality Aim 2010" – description of aims, guidelines, instructions, methods and

practices for the clinics. “Risk and incident analysis” for patient safety critical process / sub-process including action plan describing how incident reporting should be done yearly. In 2010, 31 risk assessments at 16 of the 67 clinics were conducted.

Examples of Work Environment-related documents: Policies about Healthy Work Environment including work environment investigation. The Policy document "Distribution and delegation of tasks within the work environment" describes the employer's and other executives responsible for the work environment. There were documents describing responsibilities concerning risk assessments at for example changes in operations.

Main processes- the level of somatic clinic (besides other clinics as for example psychiatry, geriatric, child care). The clinic performs qualified diagnostics and treatment, clearly linked to research, training and development. The clinic also conducts training of medical staff.

At the clinic level there were the documents "Patient Story and quality of financial statements", including action plans for quality and patient safety.

Processes - The level of the division intensive care (besides for example surgery). On Cardiology there was conducted basic and highly specialized cardiac care such as acute coronary syndrome, arytmi care, heart failure care, valvular and care of adults with congenital heart disease. Examples of documents: Competence Analysis; the training requirements that would apply to nurses and assistant nurses at the division. First-line manager - head nurse organizes and stimulates the work with work environment within the division and see to that work environment issues are regularly discussed at workplace meetings. Employee Evaluations (psychosocial work) indicates shortcomings in the working environment between among others manager / employee). Routines; PM and job descriptions for the guidance of the staff's work.

Comments: SHK (2013) has in their report found various documents concerning competence requirements in order to work at the department. All of the staff did not meet the requirements. Investigations were made concerning among others how the staff experienced their psychosocial work environment. The result of the survey showed lack in the trust between chief of staff and staff. There were written routines PM and word descriptions to direct the staffs’ work but special routines concerning allocation of responsibilities and the medical care of satellite patients was missing. Health care professionals (nurse and assistant nurse) work at the intensive care unit. They receive and place patients on single room and fill in the department log. They have the responsibility to investigate and clinically determine if the patient has for example external pacemaker. They also perform administrative work, for example: computer work, reading journals and manuals, write manual notes and medication lists. The staff preform regular clinical monitoring of the patient's status such as amount of urine, pain, fever, psychiatric / general condition. They also perform technical supervision as inserting electrodes and monitoring via screen telemetry equipment. The staff also preforms usual care and nursing care for example medicine, food, hygiene and communicate in concerns about the patient such as orally transfer and report status to another shift, communicate with the patient and family. They warn when necessary, to call duties / medically responsible doctor. In emergency cases they take part of CPR (Save and Revitalize).

Sub processes at the Nurse expedition: Technical programming and monitoring - computer screen – telemetry equipment. Documents: General routines for monitoring the patient with telemetry. Detailed instructions of the manufacturer of 366 pages (CE-labelled products). Two different simplified PM ”lazy dogs” which where produced at the IVA unit (2008, 2010). Comment: The unit Medical Technology (MT) who have responsibility for maintenance and service doubts whether the cardiovascular clinic could assist in brief instruction. MT says: - If an instruction were not correct, would all liability for the product be transferred to the unit that produced the simplified instruction. Technique – examples of medical devises at IVA unit Computer screens for MIDA-system (Myocardial Ischemia Dynamic Analysis). Computer with program for Pacemaker – external or internal.

Transmitter with telemetry (fig) IntelliVue Telemetry System M2601A) – EKG signals.

Sensor for SpO2 - monitoring of oxygenation. Monitoring central equipment with Philips IntelliVue Information Centre M3150B.

Comment: In this case, the MIDA-system or sensor for monitoring oxygenation was not used. Monitoring central equipment – telemetry. The monitors connected to the system have the same screen location for monitoring 12 patients. Data from a given bed is shown in a given sector of the screen. The sector's position on the screen varies for the same bed every time new patients are entered which has the consequence that the staff can not learn where bed seats are placed on the screen, because this continuous change as new patients are entered. Responsibility for maintenance and service = Unit Medical technology (MT).

Comment: Manufacturers have gone through the hidden log files automatically archived in the system. Red alarm is given e.g. at a systole - automatically provides auditory signal -yellow alarms e.g. when arrhythmia, can be selected not to be registered. Two yellow alarms appeared from the printed ECG recording but not recorded in the system's log files. The staff did not carry arrhythmia pager. The manufacturer of medical equipment has identified no errors.

Environment (E), Technique (T), Organization (O) – At the Nurse expedition. E, O: ”Narrow and shabby premises that are not perceived properly designed for the task." Large and small office connected by a corridor where there are administrative work places situated.” T, E, and O: Alarm signals with different sound were widespread. The sound level of the alarms could be set in different modes from the nurse expedition ". In the staff room, there was a switch that could be used to turn off the alarm sounds in the room. O, E: ” At times a large number of people were inside the Nurse expedition which was perceived distracting and tiring”. Context – System to provide cardiac care for - Satellite Patient
Satellite Patient (outsourced patient) who is enrolled in a clinic and temporarily moved to another clinic, for example, from the thorax to the heart clinic for care. Due to lack of space / overcrowding. The medical responsibility remains on the original clinic (O). Patients moving in several stages occur. The doctor (on call) that the patient is enrolled with contact and leaves medical information to the receiving department's before the handover but retains the medical responsibility. Therefore, in medical changes for the patient the first unit is in the first place contacted.

Human Work Activity – Nurse expedition. HWA: Enrolment of patients, arrhythmia, interpretation and shutdowns of alarms, report at shift changes, write records, phone calls and communication with relatives. For example oral over-reporting takes place at shift change between day and evening shift. Night shift in contrast gets information by reading patient data records (Take Care System). Only when found necessary, evening staff orally report to night shift. According to rules of procedure for nurses and assistant nurses at the departments of Cardiology (rev 18/6 2010) it should always be orally report from evening- to night shift. Job planning; distribution of inpatients is made here between nurses and placement based on burden of care (patient classification based on care needs). SHK found that there were three different documents with the procedures regarding distribution of patients (night-time) (2007, 2010, 2011). The document from 2010 was used in the incident (17/12) 2007, februari (16/2) 2010 och januari (28/1) 2011.

Human Work Activity with the satellite patient at the nurse expedition in interaction with: Organization, Environment, Technique, Context and the rest of the HTO-model, Operation, Main processes, processes and sub processes. Human Work Activity in interaction with O, P – case: Nurse expedition Work activity. (1:1) Oral over-reporting takes place at shift change between day and evening shift. Night shift in contrast gets information by reading patient data records (Take Care System). Only when found necessary, evening staff orally report to night shift. (1.2) (Deviations between HWA/O and P). According to rules of procedure for nurses and assistant nurses at the departments of Cardiology (rev 18/6 2010) it should always be orally report from evening- to night shift. (1:3) Unclear if it is the written procedures (P) and formal organization or the real work

activity and informal Organization that supports the work activity best in this case. (2.1, P) There were three different documents with the procedures regarding distribution of patients (at night) dated 17 of December 2007 16 of February 2010 and 28 of January 2011. The document from 2010 was used in the incident according to the staff while the head nurse said that it was the document from 2011 that was used.

Human Work Activity in interaction with the E, O, T, C – case: Nurse expedition, (C) satellite patient. Work activity. (1.1) (HWA) Hearing of reporting between the evening and night shift on the expedition. (1.2) (E, O) Interference from a confused patient who was assessed to need urgent transport to the neuro-radiology. (1.3) This meant that information about the (C) satellite patient's pacemaker failed and was never put in the monitoring equipment's central unit HTO-model (E, O, T, C, HWA.

Comment. (E, O, T): At times a large number of people inside the expedition, which was perceived distracting and tiring. Upon registration in the monitoring equipment it must be marked in a special box that the patient has a pacemaker for the system to detect the pulses from the pacemaker. It is possible to miss marking in the box since the system make it possible to move forward without marking and this happens due to, for example stress. (HWA) The nurses are to follow monitoring screens' registrations of medical records and act or alarm if serious deviations.

Remaining HTO-model. (O, S) Two monitoring screens for telemetry were placed in the "big and small" expedition and in two locations in the corridor and addition in the staff room (diffusion of responsibility). (E) Possibility to see and follow monitoring screens' registrations of medical records were limited as the monitors were placed behind the staff. The ability to manage and interpret the alarms (Silent, set and set alarm limits) and ECG tracings from the surveillance equipment was only possible from large and small expedition. In staff room there were also possible to swicth off the alarm signals.

5. Preliminary Discussion/Conclusions

There are several documents and procedures but they are not fully used in the actual work activity. Unclear leadership and division of labour occur at the unit. Technical work equipment acquired for patient safe care but deficiencies occur in use and when equipment failure occurs shortcomings in operating and maintenance follow. Missing routine and knowledge in dealing with arising emergencies / security occurs. Under reporting of incidents occurs where there are mistakes in the form of missing of filling in patients with pacemaker. The case shows that unclear leadership and disinformation with the system of Satellite Patient´s are serious and not quality assured patient safety care. Moving in several stages occurs risks and can give seriously consequence for patient safety and employees work environment if there aren't any safe control functions during the way.

Using the HTO- model for analyse patient case and work environment in the Health Care functions. Our experience so far is that HTO –model is easier to use for analyse isolated HWA than team as (doctors – nurses – assistants nurses) to identify skills, formal and informal behaviour and interactions between human – human. We maybe need to use "boxes" from other models for illustrate human – human interaction. We can already see risks in every level as we can use our upcoming questions to developer/purchaser and engaged employees.

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The Use of Medical Devices in Healthcare Institutions: Understanding Compatibility in Operating Room (OR) Technology

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This paper presents the methodological approach and preliminary results of a research project that aims to understand the use of medical devices (MDs) in healthcare institutions from a complex perspective. The study was carried out at a hospital located in the South of Bogota, focussing on orthopaedic surgeries. It also reflects on the challenges of working with different epistemological stances (ergonomics versus Post-ANT).

Keywords: Medical devices, Sociotechnical systems, Sociomaterial practices

1. Introduction

As part of health technologies, MDs are of great importance in safety, efficiency, effectiveness, economical, and equity terms, due to their role in prevention, clinical care, and access to appropriate healthcare. However, MDs are not just a technology by themselves, but when used, they are part of a more complex and different technology: a technology that involves many MDs and many human beings performing a specific medical process, like a surgery, neonatal intensive care, etc.

MDs have to pass through several stages to become a healthcare technology: design (and production), procurement and incorporation, and availability, the last one including usage. Through these stages many different actors decide over them and influence their performance: even if the main configuration decisions are taken during the design and production stage, the next stages play a decisive role in the final performance of the devices, when they become part of a new more complex technology. Consequently, the proper functioning of a MD during the performance of a medical procedure does not depend exclusively on the solely functional and usability features of the device, but of the arrangement and interactions with all other actors (other MDs, healthcare staff, etc) that network with it.

There is evidence of medical errors and adverse events related with the use of MDs, affecting patient and healthcare staffs' health and safety. Ergonomics and usability current research has focused primarily on microergonomic level issues like usability of devices (Martin et al, 2008), and also macroergonomic aspects have been addressed, especially through patient safety studies (Buckle et al, 2006; Pennathur et al, 2013), offering several models for tackling complexity (Carayon 2006; Karsh et al, 2014). However, researchers in this field recognised the limits of current status quo, suggesting embracing disciplines that deal with relationships among an overwhelming world of different variables.

Mainstreams of ergonomics and usability are not technology-driven, but they share the view of technological determinism (Bijker, 2006). From this perspective, despite of the contributions they have done and are doing in the MDs field, the possibilities of understanding the complex reality (or realities) in the use of MDs in a healthcare institution are limited. Therefore, a different way of assuming technology/society or object/subject is needed, as other ways of tackling complexity, beyond the addition of layered variables. It is necessary to look beyond isolated relationships, and to understand compatibility in the performance of a specific

medical procedure emerging technology. Compatibility in a medical procedure performance is far more complex than usability of a specific MD.

In line with this, Actor Network Theory (ANT) and Post – Ant approaches offer the possibility of understanding MDs as part of multiple sociomaterial practices (Mol, 2002). ANT is an alternative constructivist social theory while Post-ANT is the given name for contributions that even sharing basic concepts of ANT, developed other postulates that enhance, discuss, or modify ANT's original scope. Consequently, this research project aims to recognise medical devices' compatibility during their use as part of operating room technologies, as a sociotechnical system and as a group of sociomaterial practices, and the implications for medical devices design, procurement and incorporation. Compatibility is understood as an "appropriate interaction", and a "non-appropriate interaction" may be called incompatibility. Compatibility in a medical procedure performance is far more complex than usability of a specific MD. A more specific definition of compatibility from a usability, ergonomics and ANT viewpoints is presented in Lange-Morales et al (2011).

As this study is still under development, this paper will present the methodological approach and some first findings of the study. It will also reflect on the challenges of working with different epistemological stances (ergonomics versus ANT).

2. Method

This qualitative-interpretative study was organised in three research stages: understanding OR technology as a sociotechnical system (ergonomics approach) (Hendrick, 2000), understanding OR technology as sociomaterial practices (Post-ANT approach) (Mol, 2002), and triangulation of both approaches. The application of ergonomic tools for characterising the ergonomic system, semi-structured interviews with all involved stakeholders (director, staff responsible for MD purchasing, theatre nurses, nurses, orthopaedists, and biomedical engineers), and praxiography (ethnography of a practice) of orthopaedic surgeries were the main strategies for collecting data, including three camera types (GoPro Hero 3+, iPhone 4 and Tobii Eyetracker glasses) for recording surgeries and conversations. Informed consent (following WHO guidelines) were designed for healthcare staff, and for patients. These documents were signed before initiating observation and recording.

2.1 Understanding of operating room technology as a sociotechnical system

Several questions were asked in order to define: the purpose of the system (why is the surgery carry out?), its structure (what are its elements and how are they organised?), dynamics (how are the elements interacting?), and outputs (what are the consequences and 'products' of the performance of the surgery?). The ergonomic system (García-Acosta 2002), the MOST method (Lange-Morales et al 2012), and a guideline based on the structural dimensions of a work system proposed by Hendrick (2000) i.e. complexity, formalisation, and centralisation were used for answering these questions. Parallel to the data collection process, an ergonomic modelling process (Vidal, 2010) was initiated (and is still under development), in order to identify smaller units of analysis (subsystems) to be able to map interactions inside and among the subsystems, and finally to deduce normal and incidental variability (Vidal, 2010). This process led to the establishment of several levels (Karsh and Brown, 2010; Karsh et al 2014), facilitating the analysis considering pre-established categories. A matrix was built where all observed surgeries were crossed with all identified elements organised in the above subsystems. This allowed to locate in the crossing cells the critical interactions observed, facilitating a later analysis, codification in NVivo Software, and correlation to other sources of information. 3D modelling of the OR was used to represent and analyse the variability in the OR organisation, which varied greatly depending on the performed surgery. Based on this information, a model of the OR Technology as a sociotechnical system is being developed.

2.2 Understanding of operating room technology as sociomaterial practices

It consisted on a qualitative-descriptive-interpretative approach with ethnographic perspective, taking into account elements of ethnomethodology (Potter, 1996). According to the proposal of Mol (2002) the medical devices were understood as things manipulated in practices. A sociomaterial practice is "thus a routinized way in which bodies are moved, objects are handled, subjects are treated, things are described and the world is understood" (Reckwitz, 2002). Medical devices were not the focus, but the attention was driven to understand medical practices in concrete surgeries. This led to the construction of a praxiography (Mol, 2002) of the out coming relationships among the actors. Sources of information were in situ observation, field diaries, semi-structured interviews and voice and video recording. Through this sources, histories (Gabriel, 1998) were identified and used in the subsequent analysis.

2.3 Triangulation of both approaches

The sociotechnical approach (2.1) is more consequent with technological determinism while the practices approach (2.2) responds to a symmetric approach (in the 'middle' of technological determinism and sociological determinism). Both approaches respond to different epistemological stances. The sociotechnical approach looks into pre-established categories, while in the practices approach categories emerged from the analysis. That is why a triangulation of approaches is needed, in order link both interpretations and be able to answer the research questions.

3. Preliminary results

The hospital where this study was carried out is considered a social enterprise of the state. Due to the services they provide, it is classified as a level II (medium complexity) hospital. They offer medical consultation, hospitalization and attend urgencies in basic clinical and surgical specialities as psychiatry, gynaecology, paediatrics, internal medicine, orthopaedics, and surgery. The hospital is located at the South of the city of Bogotá, and the attended population comes mostly from a low social stratum. Many of them are even not registered in any social security system, and they came to the city because of forced migration due to violence in their towns of origin. Unlike other hospitals in the city that attend only patients affiliated to certain health promotion entities, this hospital opens the doors to everyone. The hospital was built in recent years, but half of the building is not on service because of legal problems related to corruption in the management of contracts. The current director (not involved in the previous management) is working on the solution of these problems.

Around 150 orthopaedic surgeries are performed monthly. Most of them are related with traffic accidents, home accidents or violent situations. 38 surgeries were observed and 85% of them were video-recorded with a GoPro camera and an iPhone for subsequent analysis. Field diaries of all visits to the hospital were written and voice notes of interviews and conversations with all stakeholders were taken. The recognised areas up to the moment include the planning of surgeries, performance of surgeries, and after-surgery processes, including central sterile processes.

3.1 "Grasping" compatibility in the use of medical devices as a sociotechnical system

Five basic subsystems were identified and modelled: surgery subsystem (orthopaedist, general practitioner, and all used furniture and devices, OR), theatre nurses' subsystem (theatre nurse, theatre nurse trainee and all used furniture and instruments), anaesthesia subsystem (anaesthetist, anaesthesia machine and related instruments and devices), nursery subsystem (nurse, nurse assistant and all furniture, supplies, devices and instruments manipulated by them),

and information technology subsystem (desktop computers, keyboard, mouse, mobile phone and associated furniture).

A great variability in the type of medical devices used for the same purpose was found. The built matrix allowed to cross each surgery observed with all established subsystems, allowing to locate critical interactions in the specific subsystems that were generating directly the lack of compatibility in the MDs use, with negative consequences for the healthcare staff and/or the patient.

3.2 "Grasping" compatibility in the use of medical devices as sociomaterial practices

Praxiography gives account of an historical moment, determined by the researcher's journey (or history) and project (or purpose). It is deliberated subjective, reflexive, and gives account of details. Giving account of a practice means giving account of a dynamic that takes place in a specific moment, filtered by the observer's own interpretation. The researchers give account in their narratives of many 'issues' that play a role in the use of medical devices, without concentrating or dealing with specific categories. Context is imbibed in the text,

Based on this information, different practices are being deduced, for example: preparing devices for a surgery, treating the patient before, during and after surgery, organizing the OR, solving 'controversies' around the use of devices (or the lack of certain elements), dealing with families and information, adapting OR into intensive care units (UCI) because of a massive demand of healthcare services after a football game or a public beer party.

A reflection about praxiography as the consequence of two distinguishable but at the same time inseparable issues is being also explored. On the one hand, ethnography is seeing as a process that gives account of an historical moment, determined by the researcher's journey (or history) and project (or purpose). This includes dealing with ethnography as a reflection of what is meaningful to the researchers (related to their past, their present, and their future) and how this is related to what and how they are observing, interpreting, registering, and representing "reality". It embraces also a reflection about the observation process biased by the researchers' background discipline and professional experience, including the role of instruments used for 'capturing' data like field diaries (what and how to write) and devices like smart phones, cameras and specialised registering equipment.

4. Discussion and future work

Based on the understanding of compatibility in OR as an "appropriate interaction", one could conclude that, in general, all observed surgeries there were appropriate interactions, as the main purpose of the procedure was achieved: the bone fracture was reduced, the wound was cleaned or the tendon rupture was repaired. In other words, there was compatibility among MDs and other actors. What varied greatly was the degree of effort invested by the orthopaedist and other members of the surgery team, and the healing prognosis of the patient, suggesting various degrees of compatibility. These degrees depend on the normal and incidental variability observed in the type of MD used and on the way MD were used, which at the same time depend on how the MDs were incorporated in the OR, prepared for a specific surgery, maintenance procedures, and political decisions taken during the purchasing processes. This suggests the construction of a classification of MDs based on aspects related directly to user issues (healthcare staff and patients) including the consequences on the different sociomaterial practices where stakeholders and MDs were involved.

An approach combining tools from ergonomics and from sociology of scientific knowledge and technology allows to understanding what is happening in the practices, beyond text and context, in other words, beyond processes and system. In the "doing" values and beliefs are enacted. There is no differentiation between surrounding factors and the ergonomic system. The main difference between the ergonomics approach and the sociomaterial practices approach relies on the way things are understood and explained. From a systems approach one 'sees' elements interacting within an organisation, with regulation and control mechanisms, oriented to

a common purpose. From practices theory one identifies the translation of a world vision in concrete and daily ways of acting, and how these practices are aligned and coordinated.

After finishing the study, the researchers expect to offer a more holistic way of understanding MDs compatibility, including an analysis of how ANT Post-ANT approaches can contribute in the understanding of complex systems.

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Challenges in complex adaptive healthcare systems

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A dynamic combination of several parties makes induce challenges in health care. In the framework of complex adaptive system (CAS), challenges are approached as the tensions between different management principles. We have carried out two studies focusing on change cases in a health care organisation and a social and health care network. On the basis of interviews, we identified the challenges which were revealed during the change process and examined them within the framework of tensions in CAS. The results show that change cases induce such tensions in system and they should not be ignored when a change is managed.

Keywords: challenge, tension, health care, complex adaptive system, CAS, change

1. Introduction

A dynamic combination of several parties makes health care as a challenging working environment. Chronic diseases, is moving the focus in health care from individual consultation towards a more complex multi-professional system (Ouwens et al. 2005). Integrated care interventions have targeted to control the variation in system. Formal tools like process flow diagrams and guidelines have been typically applied and the changes have been structural. The ideas of lean manufacturing have been popular in the improvement of health care processes (see e.g. Newell et al 2011). However, these attempts to standardise and simplify the health care processes have also been criticised. It has been suggested that health care should be treated as a complex adaptive system (CAS) (McDaniel & Driebe 2001). CAS is composed of independent interacting actors forming a self-organising, nonlinear and dynamic system which is uncontrollable in the traditional sense. The management of a CAS is balancing between various tensions rather than changing the formal structures. (Reiman et al 2015). This study examines the challenges which emerge when new operations models are introduced in health care. The analysis is carried out through the framework of tensions in organisational CAS.

2. Methods

We carried out case studies in two health care organisations. In the first case, a social and healthcare workgroup implemented a new clinical pathway for geriatric patients. It describes principles, activities, responsibilities, several check lists and sources of additional information which are specific for the care of geriatric patient. The initiative party was a primary health care unit. Several health and social care organisations from private and public sector are involved. The new clinical pathway guidelines were introduced in more than 20 sessions arranged for this purpose and the organisations were encouraged to apply the guidelines. The follow-up meeting of the working group was arranged six months after the introduction sessions. It was noted in the meeting that organisations have found it difficult to mobilise the guidelines even though the implementation sessions were mostly successful.

In the second case, a hospital aims to improve medical care by introducing automated medication storage devices. The new automated storages would replace the conventional medication storage rooms that are used currently. The implementation of the automated medication storages is a big project which has required years of planning and technical preparations. The case was carried out in the one of the biggest hospitals in Finland. Multiple

wards, units and actors – mainly doctors, nurses and pharmacists – were involved. With the automated medication storages, the medical treatment process is as follows: 1) the physician prescribes the medication in the medication information systems which 2) then allows the nurse an access to a medication storage 3) to get medicine to a patient. All these steps are necessary. New instructions concerning the responsibilities in the medical treatment were delivered in connection with the project. The implementation of the automated medication storages was not yet finalized at the time of our study.

In both cases we analysed the change on the basis of interviews and the material given to us. In the second case we also actively participated in the change by arranging workshops and meetings in hospital to support implementation of the change.

We interviewed representatives of the relevant organisations and professions. 24 interviews lasting 1-1,5 hours were carried out before the actual use of new guidelines and systems. The interviews were semi-structured and included five main themes: *The process to be changed; Quality, patient safety and efficiency of the process; History of the process and previous development activities; Vision of the new process; and Conception of change.*

The interviews were recorded, transcribed and coded thematically using QSR NVivo qualitative data analysis software. Four researchers participated in interviews, coding and analysis. The following results are based on the data which was coded both as an *obstacle of the change* and any of the following: *values; roles; confrontation; interaction; influence on quality, safety or efficiency; dynamics; practices and rules; change management.*

3. Results and Discussion

Reiman et al. (2015) describe the challenges within an organisation as tensions between different management principles. The four main tensions exist between: 1) standard procedures and flexibility; 2) low and high variance; 3) ties between actors: few strong and multiple weak; and 4) system goals and local goals.

3.1. Case 1: a new clinical pathway for geriatric patients

Flexibility. Implementation of a new clinical pathway would require a flexibility. However, many signs of inflexibility were presented in interviews. An interviewee has recognised that usually the personnel do not regard the improvement of their working practices as necessary even though they admit that new ideas were reasonable. The special health care personnel did not attend in the implementation sessions.

Interviewees have also noted a tendency to see elderly patients as kind of “unwanted customers”. They might require special attention or knowledge and thus deviation from normal routines. Further, an interviewee noted that the standard practices should always be adapted to the situation of an elderly patient (suggesting that it is not always done). As an example of this, it was mentioned a “standard practice” to send a patient always from central hospital to primary care hospital for convalesce even if they could be sent directly at home.

Interviewees also doubted whether the initiators would have enough power to make the change happen and insisted that the higher management should specifically determine the tools and time to be used since the voluntary change would not happen. These can also be interpreted as signs of inflexibility in the system.

As a summary on flexibility, the sticking to the standard procedures challenged the change. However, the goal of the change was adoption of new standard procedures.

Variance. The new clinical pathway aims to diminish variation by recommending guidelines and shared tools. This raises a tension with a long tradition of individualistic practices allowing personal decisions and arrangements of an independent professional. The call for independency may be related to emphasis on the personal responsibility which was repeatedly expressed in interviews. As an example, an interviewee explained that it is up to each surgeon and the operation team whether they use the recommended operation room check.

The entire goal of the guidelines is to emphasize the special needs of geriatric patients as a group. This was slightly criticized in interviews as too limiting. Instead, it was suggested that each patient should be treated as an individual, even though the need and importance of geriatric knowledge was acknowledged.

As a summary on variance, an attempt to reduce the variance with guidelines challenged the independence of professionals.

Ties between actors. Traditionally, health care consist of multiple professions forming rigid silos. Inside a profession (physicians, nurses, physiotherapists, etc.) the ties between individuals are typically strong, for example professional identity, collegial loyalty and shared experiences. Similar silos are formed on the basis of medical specialties and corresponding wards in hospital as well as different organisations in social and primary health care.

New guideline attempts to override these silos. Viewpoints of different professions and parties were considered in the development of clinical pathway guidelines. A multi-professional workgroup of 12 social and health care professionals was appointed to prepare the guidelines. The participation of patients was organised by arranging a quite extensive session involving directly 18 professionals and 8 elderly patients.

The session was criticized by an interviewed participant. She noted that the elderly patients that participated in the session were left as bystanders, the guidelines were already quite finalised and the language was quite difficult for a layperson to understand. Another interviewee suggested that the special health care personnel regard themselves as outsiders because the leader of the implementation was the primary health care unit.

In their daily work, interviewees had experienced the difficulty to take the viewpoint of other parties – both the patients and other professions. An interviewee had found that multi-professional collaboration is not a natural skill but it should be rehearsed and learned. She actually described the process of strengthening of the ties between the different professions as follows: “It requires that all professions identify their strengths and weaknesses and then consider interfaces: how the knowledge and skills complement each other and what kind of flexibility is needed.” The process also loosens the ties inside the profession when own weaknesses and need of complementary skills are openly admitted.

A manifestation of a strong tie between organisations was presented by a small provider of social care service: “We have no problems in implementation of new guidelines. As the service purchaser, the city hall has power to make us to do everything they want.”

As a summary on ties, strongly tied professionals’ silos make it difficult to make changes which require coming out of the silo somehow. Changing ties could make the change possible.

System goals versus local goals. Taking into consideration the special characteristics and needs of geriatric patients is a system goal which the clinical pathway emphasizes. This goal and related activities are relevant for most health and social care professionals but usually they have another speciality. A patient of most medical specialties may be geriatric but the geriatric aspect is additional to most medical specialities (except geriatrics). Health care is organised to serve local goals based on medical specialities and silos of professions. The approach, organisation, and structures of the information systems are optimized for diagnosing and treating traumas and diseases rather than treating the patient as a whole. A geriatric patient typically has multiple symptoms at the same time and therefore is a true challenge for current health care. An interviewee has found that nobody gets an overalls picture about the situation of the patient and very few have competence to comprehensively take care of a patient.

As summary on goals, the change introduced a system level goal which challenged the whole health care system based on local goals.

3.2. Case 2: new automated medication storages and medication procedures

Flexibility. The introduction of automated medication storages requires flexibility from nurses and pharmacists in order to learn and adopt new practices. According to the interviews, the nurses and pharmacists did not oppose this challenge (in advance) but rather were looking forward to it. They were impressed by the promised improvements in their work and working

environment which the new system would bring. It was suggested by an interviewee that especially experienced nurses feel safer during changes because they have earlier experiences on survival. Inexperienced nurses are more likely to have stronger reactions: fear, anxiety and feeling insulted. Thus, the experienced older personnel may be more flexible.

Formally, the work of physicians should not be changed, which was remarked by several interviewees. However, the introduction of a technical system challenges the flexible practices. During the planning of the new system, the planners noticed that the medication information should be without exception and correctly prescribed in medication information system by a physician. They also found that current prescription practices are more flexible in such ways that the medication information is not necessarily available in the system when it is needed. This would mean that the nurses would not get the medicine out of the automated system. In current manual system, there are different flexible ways how physicians and nurses can fulfil the medication without formally correct prescription in the system by using other information sources. Introduction of the new automated system would thus require physicians a flexibility to standardize their practices.

The instructions basically insisted the physician to prescribe the medication in the system by themselves or at least confirm it within two hours. This raised objections. Our interviewees presented situations, where new instructions would be unpractical, at least. For example, in night time, a physician may give orders for medication by phone from home. New instructions would require that either the physician would come to the hospital within two hours to confirm their orders in the system or the physician on call would do it. It was expressed that a physician on call should not be encumbered with such routine tasks since they usually are busy with acute urgent tasks.

The interviewees explained that the objections of the physicians in general are mainly against the poor usability of the medication information system. There are many evident ways of how the system could be better. For example, the system would be easier and safer to use if only relevant alternatives would available in menus. Physicians feel that the use of system takes too much time because of its inflexibility.

Nurses expressed their worries about the inflexibility of the new automated system and new instructions since the missing information is a problem for them to be solved. They were afraid of the conflicts with the physicians who will not agree with the new instructions and the resulting potentially aggressive negotiations with other physicians. They expressed their worries concerning the total seizing up of the system or running out of the needed medicine. A separate local stock of medicines for such emergency situations was suggested by an interviewee.

As a summary on flexibility, the inflexibility of the new system challenged the current flexible practices.

Variance. The instructions also required that the physician would review the overall medication of a patient when they arrive in hospital, is moved to another hospital unit or is leaving the hospital. This requirement does not take into account certain variance in system. An interviewee suggested that the review of the overall medication of (any) patient would be difficult for many physicians who know mostly only about medication for their own speciality. This lack of knowledge may make the physicians feel insecure to take such responsibility. Physicians are not formally required to update and prove their knowledge on medication as the nurses are: nurses have regular examinations in every five years.

Further, the instructions required that the review of medication should also be especially marked as done by the physician. An interviewee presented that this has been considered an unnecessary and unwanted control over the work of the physicians. This may reflect the physicians' tradition to expect certain freedom choose the practices which they regard as the best.

As a summary on variance, an attempt to control the variance was challenged by the variation in the competencies and the independence of a professional.

Ties between actors. This change would challenge the silos of professions by speeding up the changes in ways of working which may be interpreted as a new distribution of the work

between professions. Traditionally the physicians spoke prescriptions to a voice recorder, the secretaries transcribed the recordings and the nurses then transferred the information into the medication information system. Alternatively the prescriptions were told directly to a nurse. Some physicians (still) do not regard writing into the information system as their task.

The nurses assumed that their knowledge on medicines or medication will weaken when they will get the medicine from an automatic storage. One interviewee referred to the increased automation of hemodialysis machines which had weakened nurses' knowledge on the dialysis.

As a summary on ties, silos of professions is not – so far – a major challenge in this case.

System goals versus local goals. The planners of the new system suggested that health care professionals stick to the personal practices because they see only their own specific task and a local goal related to it. They are not aware of the whole medication process and their role as a contributor to a system goal: the medication of a patient. The nurses' worries about the conflicts with 'disobedient' physicians certain objection to the new system may indicate the lack of such systemic view.

As a summary on goals, it was suggested that the systemic understanding of the medical treatment process would improve the change.

3.3. Comparison of the cases

Both cases included the introduction of new system-wide guidelines or instructions but only in the second case this was a part of the introduction of a new technical system. The *inflexibility* of the technical system raised tensions with current flexible practices in the second case whereas; in the first case, sticking to the standard procedures challenged the change.

In both cases, the attempt to control the *variance* induced tension with the independence of a professional. In the second case the variance in the competencies of professionals was relevant.

In the first case, the attempt to override the effect of *strong ties* within professional and organisational silos created major challenges. However, in the second case, such a strong effect was not found.

An overall care of a patient (geriatric aspects or medication) formed similar *systemic goals* in both cases. In the first case, a tension between a system goal and the local goals based on the structure of health care system became evident in interview. On the other hand, in the second case, the topic was not clearly handled. In spite of that, a shared understanding about the systemic nature of the medical treatment process was considered as essential for the success of the change.

Analysis of these cases through a framework of tensions in CAS exposed profound differences between seemingly similar cases. Thus, the framework proved to be useful. Even though the framework was originally focused on safety management it also made sense in a more general use – at least in these safety critical organisations. The framework also includes four secondary tensions which could be the framework for further analysis.

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Simulation and evaluation of industrial applications of Human-Industrial Robot Collaboration cases

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Presented in this paper are two cases from a heavy vehicle manufacturer which demonstrate the potential width of Human-Industrial Robot Collaboration workstations. Case I simulates in machining environments, the assisted inspection of inline engine blocks and Case II simulates in logistics environments, the assisted material preparation for assembly line orders. The analysis and simulations were carried out with a software tool that combined digital human modelling, robotic simulation, path planning and use of technical computing tools. Results demonstrate the improvement of process ergonomics and cycle time.

Keywords: Human-Industrial Robot Collaboration, HIRC, simulation, Digital Human Modelling, DHM, man-machine, industrial robot.

Introduction

The retention of elderly workers by companies in industrialized nations, due to reasons of economic stagnation or changing demographics, is resulting in an increase of the average age of the workforce (Zaeh and Prasch 2007). Although workplace ergonomics should always undergo improvement for everyone, the elderly are more susceptible to musculoskeletal disorders due to the deterioration of physical human ability with age. The performance of man-power engaged in semi-automated work environments is likely to suffer as well with increasing age. Robotic automation serves as an alternative to the performance of tasks that are repetitive, hazardous and/or have requirements of high precision and/or strength. Intense global competition requiring high levels of productivity through high speed of operation also justifies robotic automation. Human workers however, possess superior sensor-motoric and decision making capabilities, and are extremely flexible to change (Krüger, Lien & Verl 2009). As full robotic automation is at times not possible to implement in certain situations due to issues of practicality and complexity, Human Industrial Robot Collaboration (HIRC) may potentially enable the inclusion of an elderly workforce in value adding processes without compromising on productivity and at times even resulting in its improvement (Reinhart et al., 2012).

Numerous applications of Human-Robot collaboration have been documented in the areas of assembly, which include: a cell production assembly system concept by Morioka and Sakakibara (2010), team@work by Fraunhofer IPA & IPK (Thiemermann and Schraft 2003), the PowerMate system by Fraunhofer IPA (Schraft et al., 2005) and COBOTS by Edward Colgate (Colgate et al., 1996).

Numerous tools for digital human modelling (DHM) and for simulating and visualizing robotic movement are in existence, however, very few tools can be found that virtually combine both human and robot. If HIRC is to become commonplace in the near future, then means for evaluation and visualization must be developed.

Objective

The purpose of this study was to simulate the possibility of HIRC in machining and logistics environments with assisted engine block inspection and assisted material preparation respectively. Virtual simulations of HIRC assembly systems have also been demonstrated by Ore et al. (2014). The simulations were evaluated with regard to ergonomics and productivity by observing the biomechanical load on the manikins and operation time respectively. HIRC solutions were proposed, analysed and compared with their manual counterparts.

Method

The virtual evaluation of human-industrial robot collaboration, for both cases presented below, was performed by a combination of a DHM, robotic simulation, path planning and technical computing tools. IMMA (Intelligently Moving Manikin) is a user-friendly, non-expert DHM tool (Hanson et al., 2014) which determines both collision free and ergonomic motions for the manikin involved in a simulated operation. Industrial Path Solutions (IPS) 1.4 is a computer-aided motion tool used for collision-free path planning. IPS 2.0 is a software tool used for visualizing and defining collision-free industrial robot movements. In order to define simulation environments of the two cases (for both the current method of work and proposed collaborative process), CAD models of the work stations were designed in a CATIA V5 environment (Figures 2 and 5), converted to a supported format and imported into IMMA where digital manikins were embedded, along with motion paths defined in IPS 1.4 and robot joint movements defined in IPS 2.0. To evaluate biomechanical load, a script was created in MATLAB which analysed every posture comprising the manikin's motion according to the Rapid Upper Limb Assessment (RULA) method (McAtamney and Corlett 1993). RULA analyses human postures and grades them on a scale from 1-7, where a higher score represents a higher risk of acquiring musculoskeletal injuries. For a realistic determination of robotic actuation times, a forward kinematics joint solver program was created (again in MATLAB) taking into account the acceleration and deceleration of joints and allowing for the monitoring of Tool Centre Point velocity. For comparison with the proposed collaborative processes, the biomechanical load and cycle times were determined for the current processes as well. The engine block inspection and material preparation processes were studied through visual observations and video recordings of the operators with an emphasis being on the placement and configuration of hand grips. 50th percentile Swedish male manikins corresponding to a stature of 1791mm and mass of 77kg (Hanson et al., 2009) were embedded and made to carry out the movements studied. The predetermined motion time system, Sequential Activity and Methods Analysis (SAM) (Laring et al., 2002) was used to determine manikin activity times for manual motion.

Case I: Assisted inspection of inline engine blocks

In the current inspection process, inline engine blocks are delivered to a rotating unit which indexes the block along predefined positions for the operator's convenience in inspecting the machined faces. After inspection the operator pushes the engine block out to be picked up by a manually controlled lifting device and palletized. The inspection process requires the operator to acquire awkward postures and an exertion of effort in sliding the blocks back and forth to gain access of features hidden from view, as seen in Figure 1 and 2. Palletizing also involves excessive movements around the work station.

Figure 1: The engine inspection environment.

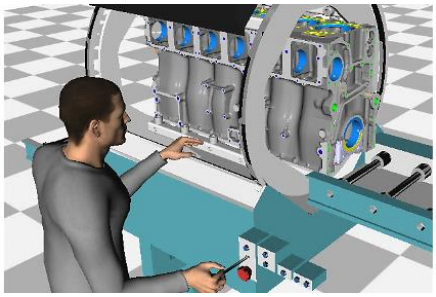

Figure 2: The virtual environment.

The collaborative inspection process (as seen in Figure 3) uses an ABB 7600-400/255 robot for holding onto and rotating the engine block along indexed positions for inspection. A Güdel TMF-4 linear track is used for horizontal movement along the station for palletizing. The robot grips the engine block from the top face, lifts it up to a convenient height and manoeuvres it for inspection along the different faces. Upon finishing inspection, the robot moves along the track and palletizes the engine block according to its respective variant. All movements of the engine block occur behind the laser light curtain at a maximum TCP velocity of 250mms^{-1}.

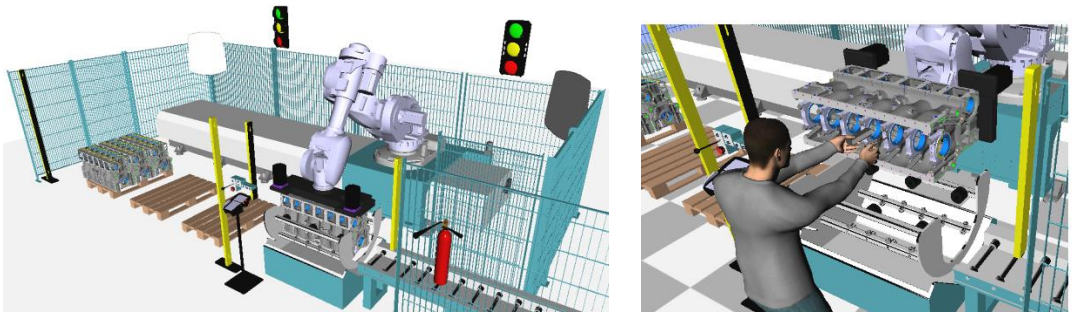

Figure 3: The assisted inspection station (left) and a manikin inspecting a face (right).

Case II: Material preparation for assembly line orders

In the current preparation process (Figure 4 and 5), driveshaft orders are prepared and delivered to assembly stations. The operator picks up driveshafts with a magnetic lifting device and places them onto a delivery pallet according to an ordered sequence. The lifting devices move along guide ways and the operator must exert an effort in order to accelerate and decelerate the lifting device and driveshaft combination. Order preparation also involves excessive movement around the workstation.

Figure 4: The material preparation environment.

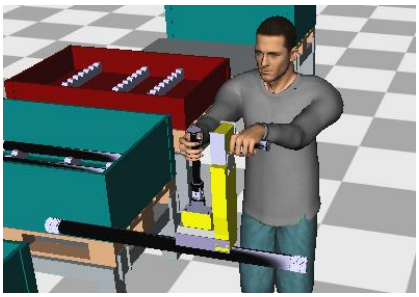

Figure 5: The virtual environment.

The collaborative material preparation process (Figure 6) uses an ABB 4600-40/255 robot for transferring driveshafts from their containment pallets to the delivery pallet. An ABB 4004 linear track is employed for horizontal movement along the station. Orders are relayed to the robot which then moves to the location of the driveshaft variant needing pick-up, once in a pick-up position, the operator approaches and guides the end-effector to clamp onto a driveshaft and moves back away to a predefined safe distance. The robot and track then move rapidly to place the driveshaft onto the delivery pallet and return to the next pick-up position. The collaborative process also allows the operator to use only one hand. For a safe collaborative operation, the robot is assumed to be equipped with a safety surveillance system which continuously monitors the proximity of the operator to the robot and controls the speed of robot and track movement accordingly.

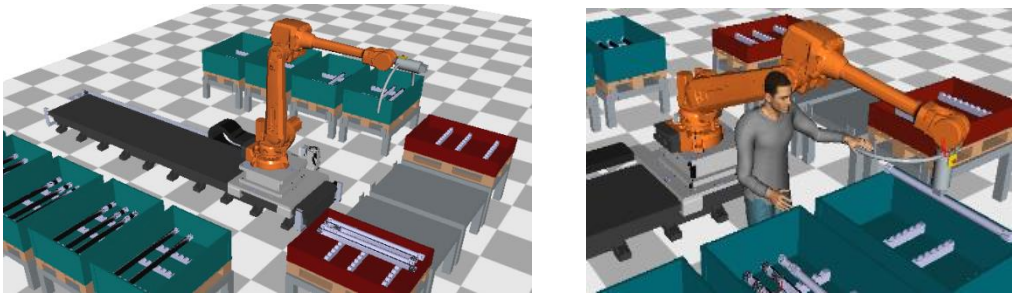

Figure 6: The assisted material preparation station (left) and a manikin picking up a driveshaft (right).

Simulation results

Simulations corresponding to the inspection sequence of one engine block and a material preparation order of 10 driveshafts were carried out with manikins and the resulting biomechanical load compared with the human-industrial robot collaborative processes. The tables below exhibit the percentage of time spent in each ergonomic zone and process times of the human and robot. The higher of the RULA scores of both arms is considered.

Case I: Table 1 results indicate an improvement of biomechanical load with the HIRC workstation compared to the current manual process, as can be easily seen in the Averaged RULA Score reduction from 4.9 to 4.3. Although with HIRC there is no significant change in the overall process time (reduction by 3.3 seconds), the operator now works for a reduced duration (116.1s compared with 180s previously) and hence has increased recovery time.

Process	RULA score								Process time (seconds)		
	Negligible		Low risk		Medium risk		High risk	Averaged RULA score	Operator's work duration	Robot's work duration	Total
	1	2	3	4	5	6	7				
Current inspection process	0%	0%	3%	43%	32%	7%	15%	4.9	180	-	180
HIRC inspection process	0%	7%	26%	25%	12%	30%	0	4.3	116.1	60.6	176.7

Table 1: Biomechanical load and productivity results comparison for Case I.

Case II: Table 2 results indicate an improvement of biomechanical load and productivity with HIRC. Biomechanical load improvement is shown by a reduction in the Averaged RULA Score from 4.8 to 3.9. In terms of productivity, the new process time has reduced by 42 percent from 248 seconds to 144 seconds. Not only is the operator now experiencing an overall reduced biomechanical load, but also a reduced duration of work. It should be pointed out that the operator's work duration includes time for operator-only movement (27 seconds) and time for robotic collaboration (44.3 seconds).

Process	RULA score								Process time (seconds)		
	Negligible		Low risk		Medium risk		High risk	Averaged RULA score	Operator's work duration	Robot's work duration	Total
	1	2	3	4	5	6	7				
Current material preparation process	0%	0%	13%	47%	5%	21%	14%	4.8	248	-	248
HIRC material preparation process	0%	0%	58%	19%	3%	19%	1%	3.9	71.3	72.7	144

Table 2: Biomechanical load and productivity results comparison for Case II.

Discussion

This paper demonstrates the use of virtual simulations of Human-Industrial Robot Collaboration in two scenarios outside the much researched areas of assembly. The results obtained, confirm the benefits which HIRC can provide in terms of improvements, in ergonomics and productivity compared with a human working without robotic support. In terms of biomechanical load, the lower scores compared with manual processes, indicate lesser physical demands and are thus suitable for an elderly workforce. In terms of today's stringent requirements of safety in HIRC, the second case presented may not be realizable due to concerns for personal safety. Due to such close proximity of operation with an industrial robot, operators in the collaborative workspace of Case II would need to be protected by combination of safety functions which include: Stop functions, Enabling devices and advanced safety systems like Minimum separation distance sensing, Limited speed during collaboration and Limited force/pressure sensing, all in accordance with EN ISO 10218-2:2011. Personal safety must be guaranteed before HIRC can be implemented on a large scale. As a result, physical barriers are the only currently possible way to design this kind of collaborative system to ensure safety of the operator.

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Human Error: Causality and the confusion of normative and descriptive accounts of performance

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That human errors can cause accidents is a core assumption of classical safety management systems, which aims to reduce the occurrence and consequences of human errors. This paper will present two interconnected lines of arguments that are contrary to the classical assumptions of causality and focus on human error. First it identifies challenges to the assumed causal connection between human error and accidents by discussing selection bias, lack of statistical contrasts between accidents and non-accidents with respect to human error and accidents, as well as the challenge of causal inferences for N=1 cases. The second line of arguments involves the conflation of normative and descriptive accounts of performance and how this hinders a structured and scientific approach to system performance. The paper ends with three principles that require a pre-hoc identification of behaviours that deviate from performance standards. This approach hopefully allows for practitioner acceptance of performance standards, a just evaluation of performance, as well as enabling proactive safety management by requiring that errors be identified prior to performance.

Keywords: Human Error, Causality, Accident Analysis, Hume´s Law

1. Introduction

A general definition of human error that encompasses most other definitions from the human factors community have been defined by Strauch (2002, p. 21) as "*an action or decision that results in one or more unintended negative outcomes*". A common claim in human factors literature follows the general form of "*human error caused xx% of accidents*". Examples of these claims can be given as "*most of the preventable incidents involved human error*" (Cooper, Newbower, Long & McPeek, 1978, p. 39), "*Studies of offshore and maritime incidents (accidents and near-misses) show that 80% or more involve human error*" (Rothblum, et al.,, 2002, p. i). Further, in a recent book Dhillon (2007) sums up existing transportation research and shows data that approximately 70 to 90% of transportation accidents in the four major transport domains (aviation, sea, rail and road transport) are the result of human error. In other words, the fallibility of human behaviour and decision-making are seen as a liability and as a cause of a majority of accidents in the majority of industrial, service or manufacturing sectors (Hollnagel, 2013).

The last decade a number of challenges to the concept of human error has been presented. These challenges involve the fact that human error is usually identified in hindsight (Shorrock, 2013), that the identification of all errors depends on a performance standard (Dekker, 2006; Shorrock, 2013) and that failing to identify a technical failure leads to claims that humans have caused the occurrence despite the lack of evidence (Dekker, 2006). Investigations of complex socio-technical systems have shown human errors can be seen as normal (Perrow, 1999) and that a system should be designed to absorb the consequences of these errors (Reason, 1997).

This paper will focus on two arguments that question the causal connection between the

concept human error and accidents. The first is an evaluation of the possibility of making causal inferences based upon the available data of human errors and accidents. The second argument is that the use of human error as a cause represents a conflation and confusion of normative and causal accounts of phenomena.

2. Causality in Social Science

Modern theory regarding inferring causality from observations are to a large extent informed by Hume (1748/2007) and the *problem of induction,* which involves the lack of justification for drawing general arguments from experience-data. The reason is that any set of observed instances cannot be known to be a *complete set* of instances (*i.e.* we cannot know that what we have observed is the totality of facts). Hence, extracting "general valid statements" from experience becomes a logical fallacy because claims cannot be both empirical (based upon specific observed instances of a phenomenon) *and* still be general in the meaning that a statement is correct without reference to time or context (Krausz, 1986). Thus, the idea that we can derive general knowledge form experiential data is defunct and fraught with logical fallacies. This becomes a particular problem for applied sciences like Human Factors.

2.1. Impossibility of causal Inference from single cases

Accidents in socio-technical systems are all exceptional to the extent that they consist of a combination of contributing factors that are unique to that incident. In the strictest sense, the inference of causality from single events (such as accidents) is impossible, as the situation does not allow for experimental manipulation of the involved factors (Shadish *et al.*, 2001). Similarly, single-case studies do not allow for the identification of empirical regularities (e.g. cannot even support a weak probabilistic account of causality) because this would require multiple observations in order to ascertain empirical data patterns.

2.2. Selection Bias and lack of contrasts between accidents and non-accidents

Another challenge is that the claims "human error have caused 80% of accidents" are based upon a selection of *only accidents*. When a sample is selected on the basis of characteristics of sampling units (such as people or events) it leads to *selection bias* which greatly reduce the validity of (causal) claims (Bareinboim & Pearl, 2012) simply because conclusions are restricted to the limited population from which the sample is drawn.

In the case of accidents – selecting only accidents to observe does not give answers to the importance of human error in accidents – primarily we have no grounds for comparing accidents with non-accidents. Table 1 below show the traditional description of the current knowledge, where human error is observed in 80% of accidents. The occurrence of human error in non-accidents/near misses is unknown.

Table 1. Cross-table indicating lack of information regarding near misses and human error

	Human error	Absence of human error	Sum
Accident	800	200	1000
Near miss	???	???	1000
Sum	???	???	2000

The lack of information on the relative involvement of human error in non-accidents hinders causal inferences to be made between human error and accidents. Also, there are very few (if any) studies that have compared accidents with near misses or successes with errors. Only recently have researchers argued that we need also to study the how's and why's of socio-technical systems ability to succeed in demanding situations (Hollnagel, 2013; see also Øvergård *et* al., 2015).

3. Conflating Normative and Descriptive Accounts of Performance

3.1. Descriptive and Normative Accounts of Performance

A descriptive account of performance describes what a system actually does (Vicente, 1999). The account must involve stating the components (nouns), the behaviours (verbs) and the interaction (relational terms) between these components. A description is a neutral representation of an event and should not include subjective judgements like ethical (right/wrong) or aesthetical (pretty/ugly) evaluations. Hence, descriptive accounts only contain the facts of some subject matter. This is both a limitation and strength.

On the other hand, a normative account of performance is a statement on how a system should behave (Vicente, 1999). The normative account involves the evaluation of an act or behaviour through the use of a performance standard (Shorrock, 2013). A normative account of performance of is a consists of three different elements – a) a *reference to an action*, b) an (often implicit) *reference to a performance standard* for evaluating the action, and c) a *subjective evaluation* of whether the act in question was compliant with the performance standard. Performance standards could be socially shared as in laws, regulations or represented by agreed standards such as the ISO 9241-210 (ISO, 2010) or they can be fully subjective as in matters of taste.

The outcome of an evaluation is dependent on the performance standard used. Any description of an act as an "error" implicitly uses a performance standard since any event that does not fulfil the requirements in the performance standard can be said to be "in error", "inadequate" or "faulty". The result is that *any success can be made into an error* by changing the performance standard.

3.2. Performance and Error: Independent Ontological Categories

The reference(s) are implicit when the behaviour or standards are not described in the argument. The effect of this is that by removing the description of what actually occurred we end up with an indirect, non-descriptive and normative claim that bears the guise of a causal explanation.

Hence, following the idea that any normative argument is a compound of different subject matters (actual acts, subjective evaluations and performance standards) that are of different ontological categories that occur at different places and with different goals, we can say that a normative evaluation of an event cannot be used as an explanation of that event since the normative argument involves subject matters (performance standards and subjective evaluations) that was *not present* during the occurrence of the act in question. Hence, a normative account has similarities to contra-factual reasoning – which is about something completely different than what actually happened (Dekker, 2004).

In this sense we can say that any normative evaluation of performance conflates normative and descriptive accounts. It, therefore, cannot be used as an explanation since a failure to comply with a performance standard is not sufficient to produce the event (unless compliance with the performance standard is the goal).

Illusory explanations. Explaining events using absent phenomena can be compared to wishful thinking in the regard that counter-factual arguments always can be brought to bear on any situation. Using counter-factual argumentation as in "*If the person had done something different the outcome might have been better/worse*" equates to building a legal case based upon an imaginary sequence of actions. This gives the comfort of an (illusory) explanation, rather than trying to explain the events that actually took place.

As a rhetorical game, assume that a situation where a car has driven off a road with 60 km/h speed limit and collided with a three. A non-normative description of the event could be something like this "*the car entered the turn in the road doing around 90 km/h. The car lost friction, slid sideways out of the road and hit a tree beside the road*". The latter argument describes the factual occurrences and connects the action with the outcome without making a normative evaluation of the action. In this case the facts are preserved without leaving room for

impression or normative interpretations of the facts. The all too common arguments "human error caused the accident" or "the driver went too fast" does not add anything to the description of the event. The causal nature of the events is fully included in the descriptive account and no normative evaluation is needed to give an account of the events.

4. A Proactive Definition of Human Error

As noted by Strauch (2002) there is an understandable tendency to apply the knowledge of the accident *in hindsight* when we are trying to understand the decisions made by the involved operator(s). Information that one in hindsight knows was critical to successful performance is focused upon, while the operator´s point of view is ignored (or cannot be known). In this way, we create meaning where there were none for the operator. Hence we engage in contra-factual storytelling that are more about meaning making than science (Dekker, 2015).

So, should we stop using the term human error – as advocated by Shorrock (2013), or may the concept, which has drawn much interest and fruitful discussion in the past decade, still be usefully applied? To escape the dangers of hindsight, as well as the described fallacies of connecting normative and descriptive approaches to behaviour to make a seemingly causal argument, principles that lead to a proactive definition of human error is presented. The three principles are described below.

1. Only actions by the human operator that have been described in a company´s safety management system as unsafe *prior to an incident* and entered into the company´s training program can be called "Human Error".

In this way, the case of human error would amount to a deviation from known procedure which has been trained thoroughly. The classical reactive safety management approach of "reducing human errors" (an approach which is still much used) can be turned into something proactive by requiring that organisations must make explicit risk evaluations where they evaluate probable (and improbable) actions that a human operator can be expected to make. The identified errors should then be taken into the training and assessment systems of the organisations and operators should be trained in the proper handling of unexpected critical incidents where human error would be expected (Nazir, Manca & Kluge, 2013).

2. Naming an action as an error in hindsight is not allowed unless the action is specifically stated in the safety management system.

Following this requirement it is up to the safety management system and the associated training regime of the organisation to identify errors before they occur. By disallowing the use of evaluations in hindsight the investigators can then focus on the event itself instead of looking for (human) errors. Also this principle would allow us to appreciate Woods and colleagues´ definition of human error as an error only if the operator viewed the action "*at the time the act was committed or omitted*" (Woods *et al*., 1994, p. 2). Hence, by describing which type of acts that are seen as errors prior to events taking place we achieve three goals – 1) we can appreciate the operator´s viewpoints in evaluating 'novel' occurrences of human performance prior to accidents, 2) we achieve a level of organisational justice by pointing out which behaviours that would be seen as negligible - thus moving towards a just organisational culture (Dekker, 2006), and 3) we ensure *double-loop learning* where we in addition to evaluating performance also re-assesses the performance standards which is used to evaluate performance and goal-attainment (Argyris & Schön, 1978).

3. Descriptive and Normative accounts of performance should be presented separately.

Human factors specialists should attempt to keep description and evaluation of actions separately as a combination of these two often leads to illusory explanations. Similarly, when we make a normative evaluation/statement the performance standard should always be explicitly described and the exact deviation from that performance standard should be described and explained.

5. Conclusion

Recently Shorrock (2014) questioned, "*Is human error the handicap of Human Factors?*". I concur; somehow, we have seen a human factors concept being adopted outside the circles of human factors specialists, and 'human error' is often used by laypersons (and the media in particular) to identify "the cause" of an accident. This is strictly non-scientific as have been shown by the previous arguments. For human factors to remain scientific we need to avoid making use of simplistic 'common sense' statements that do not hold up to scientific scrutiny.

For singular events a descriptive account of the timeline of events and the involved components in combination with the admissible performance standards will suffice to get a full overview of the event. The addition of post-hoc causal statements will not add anything to the understanding or description of the event – besides letting us know something about the inferences made by an observer or evaluator of that event. Normative evaluations will always tell us more about the evaluator than about the event – simply because the act of evaluating will be based upon the ethics/aesthetics of the evaluator – and do not describe the performance as such.

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PU²B-model, connecting Human Factors and Systems Engineering for effective Product Development

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This paper exemplifies the close relation that is need between Systems Engineering and Human Factors if systems under development are to be proficient. The relationship between the two domains is elaborated through the PU²B-model, Product Utility Usability Business Model, which is a high level meta model developed to support decision making in systems design. The PU²B-model will present how the two fields, Human Factors and Systems Engineering, relate to each other and can be combined to get the most out of both.

Keywords: Model Based Systems Engineering - MBSE, User Centric Systems Design

1. Introduction

Complexity of product part relationships are expected to grow, both within and between products, as products become more intelligent with a higher degree of connectivity. This calls for methods that clearly connects the business cases and expected use of product to the user needs and expectations. Ergonomics and human factors can be an efficient link between business and product development. This paper presents the PU²B-model (Bligård and Nilsson, 2015), Product Utility Usability Business Model, as a platform for exemplifying the role of Human Factors in Systems Engineering. The PU²B -model connects business aspects to technical views for a system under development based on user centric design. To develop products from customer perspective has been central the last decades "Competitive advantages accrues to firms that can bring a technology into the market place in a product that meets the customer needs efficiently and in timely manner" (Wickelgren, 2005, 2nd source ref: Clark and Fujimoto, 1991, p.96).

2. The field of Systems Engineering

As complexity increases, a complete system perspective becomes more interesting. One explanation for the growing interest of Systems Engineering is the last decades' technological advances that enabled smaller electrical components and introduced software as a common part of products. Several traditional mechanical areas have become mechatronic. One example is the car industry where Electronically Controlled Units has grown extensively in the new millennia. This has in turn resulted in a substantial increased level of products inter and intra connections. A higher level of connections has brought complexity and an increased need for understanding product use perspectives and product structure during development. Several of these issues are not new for the Human Factors domain and established theories and methods could therefore be of interest to highlight during Product Development. The fields of Human Factors and Systems Engineering are in some sense closely related. They share several theoretical perspectives e.g. Systems Theory.

The assumption of mutual interest of Human Factors and Systems Engineering to co-exist efficient is the common objective to affect product development. The structured approach of Systems Engineering, providing an explicit organization of areas to be treated and issues to be solved for life cycle perspective, has put Human Factors in a natural context for product development. PU²B-modell shows how Human Factors and the structured approach of systems engineering can be combined to achieve higher potentials in product development.

Model Based Systems Engineering is one way to apply Systems Engineering. By using modelling languages and notations like UML and SysML complex relationships can be structured. The PU²B-model is based on basic notations of these languages in combination with user centric design approach to create a complete product model from business to technical solution. The model offers explicit connections of issues related to business and technical perspectives and enables product development with both quality and clear safety aspects in a lean way.

3. The model

The PU²B-model connects Human Factors, representing the customer and user perspective, to the technical perspective in product development which is related to system optimization. The PU²B-model is structured in two dimensions. One is abstraction level and the other is model object type.

3.1 Abstraction levels

To clearly show relationship between abstraction levels and objects is the main reason for the development of the model. If issues are not divided into different abstractions levels all type issues are mixed which makes conscious decision making related to the product development more difficult. How proposed technical changes affect the business, user or technical solutions is of interest if you want to view the product from a complete system perspective. In opposite are new input for business or user constraints important to know to be able to optimise technical solutions. To cover all aspects of a product three levels of abstraction are used:

- **System definition** aims at clarifying the value for the customer/user and user needs. This abstraction level is used to create clear system boundaries for the System Of Interest (SOI). The system is treated from outside as if no knowledge of how the system is operating inside is known, “black box” perspective.
- **Product definition** focuses on the use of the system and identifying the main parts of the product that will constitute the SOI and how the main parts are connected. The system is treated from outside as if some basic knowledge of how the system is operating inside is known, “grey box” perspective.
- **Architecture definition** aims at clarifying how parts are connected within the system to deliver the needs. Detailed user perspective and procedures are further elaborated. The system is treated from outside as if all knowledge of how the system is operating inside is known, “white box” perspective.

3.1. Model objects

The main contribution from Human Factors in the model development was the application Activity Theory (Karlsson, 1996). By elaborating subject, object and mediating artefacts the structure of the PU²B-model could be developed, see Figure 1. To get the most of the PU²B-model the different model objects should be connected. Which model objects that are connected depends on the issue to be evaluated. Following activity theory a **use case** on one level can be seen as part of requirements that together with the **structure** objects, on a one step lower abstraction level, will make it easier to identify needed **function** on the lower abstraction level.

Through five model object types issues of the same type can be resolved on different abstraction levels. This allows clear structure and makes it easier to properly address issues and constraints. The five model objects are:

- **Structure:** shows what parts the system consists of to both enable analysis and unambiguous design criteria and requirements.
- **Function:** shows what's expected from the system and different parts. These changes the systems states and/or modes.
- **Activities (Use Case):** How the system achieve goals and cooperates with other contexts (dependent of abstraction level).
- **Design:** describes the solution at the abstraction level
- **Requirements:** statements of what's essential to obtain in order to be prosperous at the abstraction level.

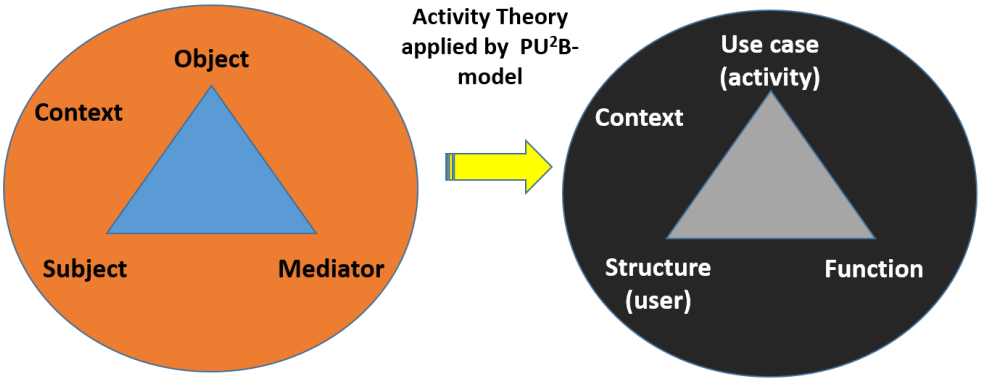

Figure 1. Activity theory translated to application of the PU²B-model.

The main contribution in this paper is the guide for assigning issues related model objects to an abstraction level where the issue can be treated consequently according to the product model. Each model object has a specific goal and purpose which is presented in the table 1. Figure 2 lists examples of model objects in relation to a food turner.

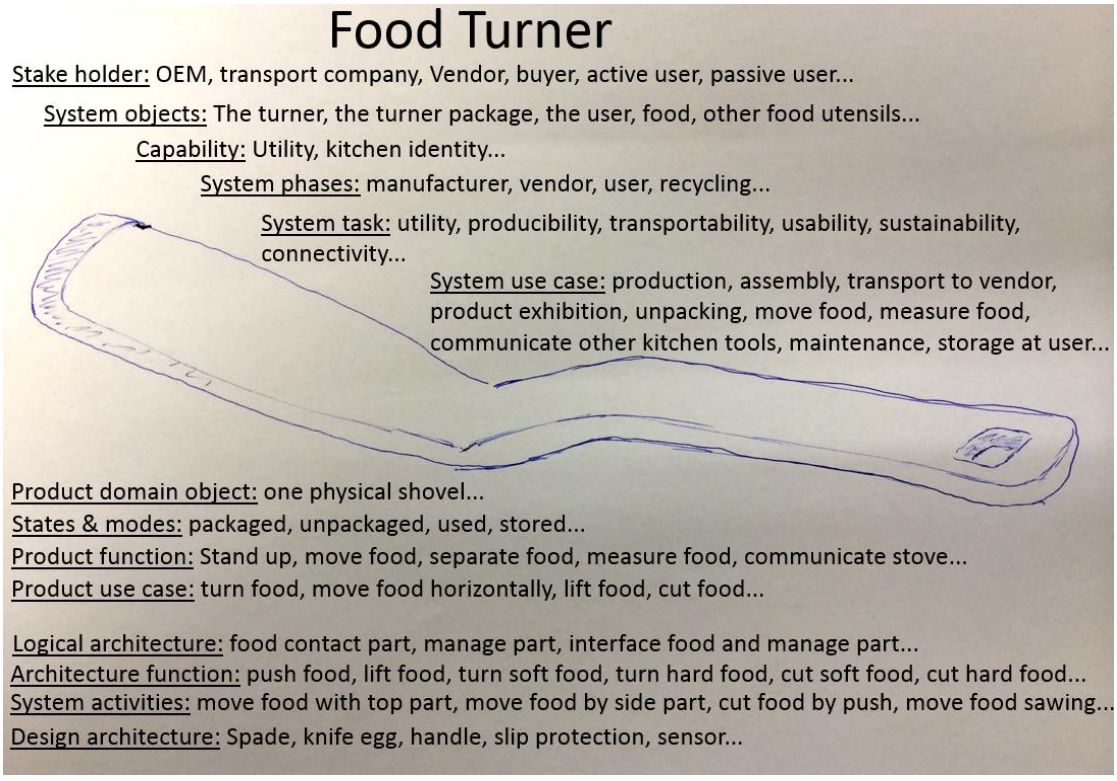

Figure 2. Example of model objects for a food turner.

Table 1. The goal and purpose of model objects in relation to abstraction level.

Abstraction level	Model object	Goal	Purpose
System definition	System stakeholder *(structure)*	Identify stakeholders: owner, user, technician…	Enable identification of needs by stating stakeholders.
	System object *(structure)*	Identify the main objects of interest in the system.	Identify the system of interest (SOI) boundaries.
	Capability *(function)*	Define what the system is to achieve, to deliver value.	Satisfy all stakeholders.
	System task	Define what the system is supposed to be delivering.	Identify what needs to be done to deliver capability. Stakeholder perspective.
	System phase	Identify phases for the SOI	Enable analysis of what changes in relation to the planned product life cycle.
	System use case	Identify use contexts that has to be considered.	Sets the stage for analysis and enables identification product domain objects.
	System req.	Define requirements	State system needs
Product definition	Product domain objects *(structure)*	Define product main parts, “the big picture”.	Identify the main components of the product.
	States and modes *(structure)*	Clarify different states/modes that the product can be set in and work in.	Means for analysis or simulation of the product and identification of product functionality and use cases.
	Product function	Define what the product should do in system use cases, based on product domain objects and states.	Clarify “what” the system shall be able to do from system perspective (not from user perspective).
	Product use case	Define activities describing product functions.	Part of requirement for architecture.
	Product req.	Define requirements	State system needs
Architecture definition	Logical architecture *(structure)*	Define constituents for product domain objects and their main interfaces.	Enable product functionality based on product use cases and requirement.
	Architecture function	Identify functionality for product constituents.	Clarify high level solution.
	System use case	Define use cases in relation to product constituents	Clarify what constituents of product domain objects are to deliver how part of the product are to deliver functionality
	Design architecture	Present detailed solution of objects and interfaces	Clarify how parts of the product are to deliver functionality
	Architecture req.	Define requirements	State architecture needs

5. Discussion

The main objective of developing the PU²B-model was to create a language for communication in work related to product development. A language that would suite different roles like: business analyst, system responsible, project leaders, system architects and not the least human factors engineers. One of the benefits of using the PU²B-model is that it enablers documentation of implicit knowledge and allows a common ground for all stakeholders of product development.

The main contribution from the field of Human Factors is the application of theories related to Activity Theory (Karlsson, 1996). By pointing out subject, object and mediating artefacts the structure of the PU²B-model could be developed. One argument for the effectiveness of the model structure is that no matter what level of system design that is to be considered it is very difficult to solve problems if there is no context to relate to. The authors experience that particularly the model objects of the first two abstraction levels are of interest. The third abstraction level is well covered in traditional modelling literature spanning over different development processes, modelling languages and notations.

A model that is supposed to be easy to grasp has the deficiency of not covering all detailed aspects. The PU²B-modell requires knowledge of how to work from an end user perspective. The model is not a substitute for user centric design but rather a tool for user centric design approach in product development. To cover all aspects of complete product development or to understand more specific issues of human factors, like attitudes and behaviour, or technical perspectives e.g. interfaces and signals other methods specialized in these areas needs to be engaged. The Human Factors domain covers several methods to support the work of defining system definition and product definition (Stanton et al.,2004). In the example of figure 2 all objects are listed in text but when working with the PU²B-model we propose to make block diagrams with relationships, to write use cases or to draw activity diagrams according to conventions in model based engineering. Using the structure of the model enables efficient handling of costs in relation to expected value as well as issues of system safety.

Product development in industry normally has a quicker pace than corresponding work that traditionally develop methods at universities. In most applications the rigorousness for true or false is not required in the same way in industrial development as during research at universities. The issue of pace and time consumption related to use of methods has thus traditionally lead to an inherent method conflict. Who is the method to support? The PU²B-modell, based on traditional research, developed to solve industrial needs may perhaps work in both domains or as a bridge between. One important strength of the PU²B-modell is that it can be applied in parts and combined in different forms.

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Training Simulator for Extreme Environments

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Current technological advancements have enabled the achievement of excellence in design of training simulators. This work highlights the challenges faced by operators in extreme environments and harsh conditions in an attempt to underpin the necessary features of extreme training simulators.

Keywords: Training Simulator, Extreme Environment, Performance Assessment

1. Introduction

The use of training simulators have gained extensive attention in recent years. The possibilities of simulating various scenarios, enabling the operators to learn, practice and acquire skills, the reduction in cost of training simulators, and the ease of availability are some of the attributes towards the increase in use of training simulators. When it comes to operator training simulators (OTS) it is rather common to find software tools devoted to Control Room Operators (CROPs) by the industrial or maritime workers. Training of Field Operators (FOPs) is less frequently addressed, as it requires immersive environments where 3D representations of the working site allow reproducing the real in-the-field experience. Usually, OTS for FOPs feature virtual reality augmented virtual reality, 3D spatial sounds, and stereoscopic vision (Manca et al., 2013). All the same, even advanced plant or vessel simulators lack important features related to both extreme work environments and harsh conditions.

The term "extreme environments" identifies working sites and conditions that are severe and dangerous for operators or may affect their health. Most extreme environments are given by weather conditions mainly linked to very hot/cold temperatures, and intense humidity. Similarly, extreme environments are also those featuring high altitude, lack of gravity, positive/negative accelerations, deep depth, lack of light, high wind velocities, etc.

The term "harsh conditions" identifies characteristics also found in conventional/normal environments where loud noise, presence of toxic components require the operator to don individual protective devices that may significantly impact on their performance by impairing their movements, reduce their breathing capabilities and in general be a detrimental point for their activities.

Both extreme environments and harsh conditions call for a new generation of OTS capable to cover those issues. Once the ETS is designed, programmed, and deployed a new problem arises, which is about the critical points of training with ETS. The trainers should be aware of the challenges and modifications of performance, capability, and situation awareness that FOPs/seamen encounter in extreme environments. For instance, training period should be inversely proportional to the low/high temperatures faces by the FOP. Lack of proper lighting conditions impairs the operator efficiency. Loud noise may reduce the capability to exchange

information with CROPs. Remote instructions may also be misunderstood or misinterpreted in case of problematic communication between operators.

The paper is provided into 4 sections. Firstly, an introduction of operator training simulators is provided which is followed by brief details on extreme environment as well as harsh conditions within the context of process and maritime operations. Some insights are provided into the performance assessment methodology for ETS before conclusions. On account of limitation of space, this paper provides insights to the concept of ETS, which will be followed by a comprehensive journal paper.

2 . Operator Training Simulator

The Operator Training Simulator (OTS) is a replication of parts or all of the screen-based control system and the safety system in the control room. The safety system provides to levels of protection against undesired events and hazard conditions (HSE risks), and is independent of the control system (ISO, 2003). The alarm and communication system, including loudspeakers, telephone and portable radios, are used to warn and guide personnel in the event of a hazardous or emergency situation. (The Norwegian Oil Industry Association (OLF), 2008) The control room operators communicate with the field operators using radio communication and monitor the outside operations via CCTV cameras.

Many of the commercial OTS include automatic operator assessment tool based on pre-made fixed scenarios. An overview of the largest operator training simulator vendors in the oil and gas industry is listed in Table 1 (Abel & Avery, 2012).

Table 1: Largest operator training simulator vendors in the oil and gas market in alphabetical order (Abel & Avery, 2012)

Vendor	OTS product	Website
ABB	Symphony, 800xA	www.abb.com http://new.abb.com/control-systems/service/customer-support/800xA-services/800xA-training/800xa-simulator
AspenTech	HYSYS Dynamics Run-Time, aspenONE	www.aspentech.com
DNV GL AS	Stoner Pipeline Simulator	www.dnvgl.com
Emerson	DeltaV OTS	www.emersonprocess.com
Energy Solutions International	PipelineTrainer	www.energy-solutions.com
GSE systems	EnVision, JPro	www.gses.com http://www.gses.com/training-simulations
Honeywell	UniSIM	www.honeywellprocess.com
Kongsberg	K-Spice, LedaFlow	http://www.kongsberg.com/en/kogt/
Mynah technologies	MiMiC	www.mynah.com
RSI	IndissPlus	www.simulationrsi.com
Schlumberger	OLGA	www.software.slb.com
Schneider-Electric (Invensys)	SimSci DYNSIM	http://software.schneider-electric.com/simsci/
Siemens	SIMIT	www.industry.siemens.com
Yokogawa	VMmaster, OmegaLand	www.yokogawa.com

When a virtual reality environment is connected to the control room part of the operator training simulator, the field operator can play her/his part into the simulation scenario. The (control room) operator training simulator can be connected to the virtual reality environment for example through a TCP/IP-link, thus, transferring data on control room operator actions and

process measurements from the OTS to the VR environment, and the field operator actions from the VR to the OTS environment. Nazir and Manca (2014) have covered the technical details of training simulator with immersive environment. The effectiveness of such training simulator was experimentally verified by Nazir et al. (2015), where they have compared the performance of participants based on distinguished training.

Extensive academic studies in virtual reality environment have been conducted related to safety and assessment (Manca, Brambilla, & Colombo, 2013; Nazir, Sorensen, Øvergård, & Manca, 2015), and learning transfer between VR environment and work situation (Ganier, Hoareau, & Tisseau, 2014). In recent years, applications of virtual reality simulator to operator training have appeared in the petroleum and power industries (Coppin, 2013; Keldenich, 2015).

3. What are Extreme Environments?

The term extreme environments (EE) entail places where living organisms can survive after some adaptation. However, those places call for quite a difficult survival and may bring organisms not yet adapted to a short if not ephemeral existence. High/low temperatures and pressures, low oxygen contents (for aerobic organisms), high exposure to radiation, acid/basic/salty conditions, water deficiency, and presence of polluting/toxic substances are just a few examples of EE.

EE may include work on the Earth in outer space or in the depth of the ocean space. The exposure of such operators to EE may be reduced to few seconds/minutes and usually does not go beyond 8 hour shifts even if a fraction of the conditions characterizing EE may be suffered for longer periods (for instance operators living and working at high altitudes for prolonged time). These operating conditions may induce short to medium-term adaptation of workers (i.e. weeks, months), where long-term adaption is the one that occurs to living species over ages (i.e. human evolution). However, there are a number of places/conditions where no short-term adaptation is achievable (e.g., very low oxygen content, extremely low/high temperatures, radiation exposure, extreme wind velocities, toxic concentrations beyond safety thresholds). With respect to living organisms, human beings have developed the capability of temporarily adapting to environments by donning protective measures that make their survival less hard. Indeed, EE conditions may be somehow mitigated by specific clothes and wearable devices (e.g., overalls, helmets, protective shields, earplugs, air bottles), which all the same, may also play a hampering/coercing role with respect to normal operating conditions. Temperature and pressure are probably the most important variables that hamper the work of operators with further elements such as wind, noise, gravity, external forces, radiation, humidity, lack of oxygen, and lighting conditions playing a synergic role in increasing exposure, inconvenience, stress, fatigue, and weakening.

4. What are Harsh Conditions?

The term harsh conditions (HC) can somehow be put beside extreme environments. This paper refers to HC as either artificial environments or artificially induced conditions that take the operator far from nominal/standard working conditions. Instances of HC can be:

- the engine room of a ship where temperature, humidity, and noise can be heavily in excess of comfort thresholds;
- mining operations where temperature, humidity, noise, darkness, and air properties usually do not meet standards or work at the surface
- a bathysphere where extreme silence broken by sudden and unexpected cracklings, darkness, and the angst of mechanical risk can distract the attention and concentration of operators;
- (non)periodic alternation of light and dark with possible flashes as in welding activities, or flashing environments;

- external operations in airports with loud noises, flashing lights, high wind speeds from engine turbines;
- (petro)chemical sites with loud noises, variable lighting conditions, odours, and toxic atmospheres;
- Ocean-going chemical tankers with isolation from the outside world, cramped spaces, and restricted areas where breathing masks and protective overalls must be donned independent of the alert level.

It is worth pointing out that this paper does not focus on workplace health and operator safety. Rather, we are interested in highlighting how discomfort, nuisance, unease, affliction, distress, and pain can modify the working capability of operators and limit their ordinary ability to carry out specific tasks. These elements of inattention diminish the situation awareness (SA) of operators and can impact on their efficiency and skill by inducing fatigue or bodily discomfort. In addition, fatigue and discomfort may lead to slips and unintentional erroneous actions, which are among the highest causes of abnormal situations, near misses, and possible accidents in industrial, maritime, and military/space environments. For this reason, we will emphasize the discomforts and disorders produced by short (i.e. acute) exposure to either EE or HC and overlook long (i.e. chronic) exposure to hazardous sources. Our target is to stress the importance of being concerned about those elements to improve the preparedness of operators by suitable training methods and tools.

The aforementioned points highlights some of the many challenges realted to EE and HC which shall be considereted during the development of ETS.

5. Assessment of ETS

The success of any training simulator should be judged by the transferability of training (Grossman and Salas, 2011; Manca *et al*., 2014). The evaluation of training can be conducted by using well-defined performance indicators. Such performance indicators can be developed in accordance with the tasks, conditions, and challenges faced by operators/seamen in extreme environments. Even though the advancements in training simulators can be seen in recent years, little is done on the assessment methodology of the training simulators. Therefore, we will like to consider the assessment feature in the development of ETS rather than considering it after the development. Thus performance assessment will be achieved by developing suitable performance indicators, which can be conceptually represented in Figure 1. The details of development of performance indicators, their categorization, and implementation in training simulators can be found in Manca *et al*., (2015).

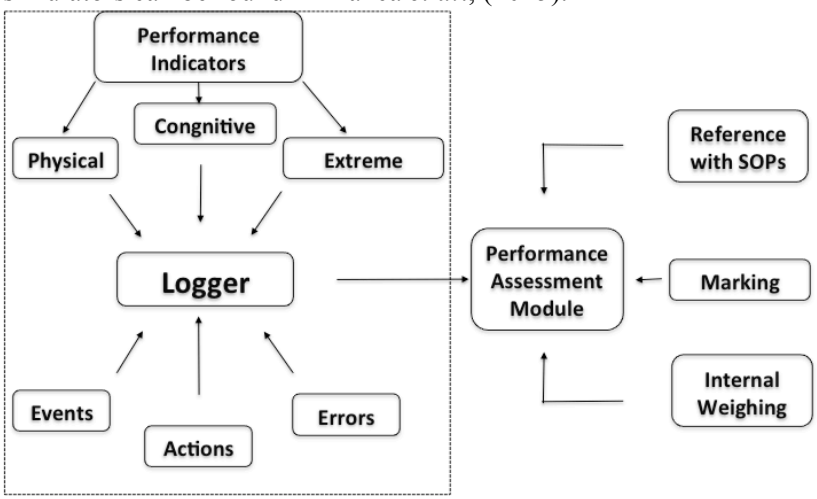

Figure 1 Conceptual framework for Performance Indicators (PIs) for ETS

As ETS is focused on skills required in extreme environment, therefore, it would be essential to conduct detailed task analysis before devising the performance indicators. Experts may collect

the data regarding PIs through questionnaires and interviews. While, the weighing criteria can be developed by using well established mathematical tools (for instance Analytical Hierarchal Process; Saaty, 2008).

6. Discussion

In recent years the gap between how the work is designed and how the work is performed has been a topic of interest for researchers as well as for practitioners. Unfortunately, the challenges faced by operators/seamen in extreme environments have been under the shadow of Human Factors research. That technological revolution has dramatically changed the roles and goals of operators. Nevertheless, certain extreme environments (e.g., intense temperature, climate, noise, vibrations, sea waves, heights, etc.) are unavoidable. Evidently on-the-job training is not a viable solution for such conditions. Current technological advancement provides the possibility to simulate extreme environments, where operators can be acclimatized, trained and assessed before embarking those tasks, and where safety procedures and drills can be trained to reduce the dangers of accidents and injuries on the job. This paper has provided some insights into extreme environment and harsh conditions with the hope of encouraging more research on this area which may result in advance Extreme Training Simulators (ETS).

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A longitudinal study of the impact of age and job demands on wellbeing for younger and older white-collar workers

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The purpose of this longitudinal study was to analyze whether high mental work demands interacted with age to predict mental problems and psychosomatic symptoms. The sample consisted of 881 white-collar worker in the lowest and highest quartiles respectively, from a British survey study. After controlling for baseline values of the outcome variables, work demands but not age showed significant main effects for the outcomes. The age X demands interaction significantly predicted mental problems as well as psychosomatic complaints.

Key words: Older workers, Mental work demands, Mental problems

Introduction

The average age of the population as well as of the workforce has been increasing in most industrialized countries. The ratio of persons in between the categories - older citizens and traditional work-active ages has been and will continue to be reduced in the decades to come (Buckle, 2015; Nilsson, 2012; Salomon, 2012). This is likely due to numerous factors including improved health and longevity and relatively low birth rates. Furthermore, the gap between the supply and demand for talent in the labour market is increasing, not least due to longer periods of education before entering the labour market and vocational and technical skills shortage. All these demographical and economical changes have put pressure on older workers to remain in the workforce for extended periods, and employers need to reconsider their workforce planning strategy using demographic, organisational process and workforce attitudinal data.

While older workers have more experience and may have acquired more tacit knowledge (e.g. how to lead and innovate) in their work roles, it is also the case that some workers may experience mental and physiological restrictions in relation to adaptability. For example, Nilsson (2011; 2012) found the presence of high mental work demands to be one of the main reasons for older worker to feel unable to extend their work-life up to or beyond 65 years. In a cross-sectional study among Swedish maritime engine officers, Rydstedt and Lundh (2012) found higher age, high work demands as well as their interaction to relate to increased mental strain– also after controlling for trait Negative Affectivity. In a longitudinal study following a large cohort over the seven years period before and after retirement, Westerlund, Kivimäki et al. (2012) found that while health problems increased with age, the transition from work to retirement was associated with a considerable and lasting drop in self-reported health

complaints. The relationship between retirement and improved health was stronger for persons with poor previous working conditions, e.g. high mental demands, while persons with previously "ideal" working conditions (low demands, high occupational grade, high job satisfaction) did not report any health improvement by retirement, thus demonstrating a cause-effect relationship.

Objectives

Further knowledge is required on how to support workers in adapting to work demands by maintaining mental wellbeing and health as they get older. Therefore, the purpose of this longitudinal study was to analyse the impact of the interaction between age and job demands on mental wellbeing and psychosomatic health among white-collar workers.

Method

The sample for this study consisted of 881 white-collar workers in the lowest and highest age quartiles (-35 and 50+ years respectively) who participated in both waves of data collection (about 15 months apart) in a longitudinal nationwide British survey investigating the relationships between physical and psychosocial working conditions, health and wellbeing (Devereux, Rydstedt el al., 2004). The mean age in the younger quartile was 29.5 years, and 54.2 years in the older quartile; 51% of the younger and 61% of the older participants were females. The average number of working hours was 40.1 in the younger quartile and 39.9 in the older quartile.

Baseline job demands were measured by the Whitehall-II version of the JDC-scale (Stansfeld, Head & Marmot, 2000) (alpha =.66) including four items, and dichotomized by median split. The two outcome variables were mental wellbeing during the past week, measured by the 12-item version of the General Health Questionnaire (GHQ12; alpha=.85), and psychosomatic health during the past month, measured by the NIOSH scale consisting of 16 diffuse symptoms (alpha=.79).

Results

After controlling for mental wellbeing measured at baseline, job demands (F=21.64; p=.000) significantly predicted this outcome about 15 months later. While age showed no main effect (F=0.75, ns), there was a significant interaction between age and job demands (F=4.23; p=.043), indicating that older workers with high job demands reported elevated problems affecting mental wellbeing.

After controlling for psychosomatic health measured at baseline, job demands also significantly predicted this outcome about 15 months later (F=9.017; p=.003). Similar to the analysis for mental wellbeing, age showed no main effect (F=0.28; ns) on psychosomatic health. On the other hand, high age and high job demands interacted significantly to predict an increased frequency of psychosomatic symptoms (F=4.59; p=.032).

Discussion

High job demands significantly predicted mental and psychosomatic health problems among older white-collar workers. Furthermore, increased age also interacted with high job demands to predict increased mental as well as psychosomatic complaints, despite the fact that age in itself did no main effect on the outcomes.

The presence of interaction between job demands and age indicated that high job demands may have particularly negative consequences for mental well-being and psychosomatic health among older workers. These findings are line with previous studies (e.g. Devereux & Rydstedt, 2009; Rydstedt & Lundh, 2012). A qualitative study with engine room officers in the Swedish merchant fleet by Lundh and Rydstedt (under revision) found that older officers, compared to their younger colleagues reported that the downsized work organization and the increased number of work-tasks requiring computer skills were particularly demanding. It is probable that these aspects of modern working conditions are experienced as more demanding among older workers than in other sectors of the labour market.

Based on their findings Westerlund, Kivimäki et al. (2009) suggest a need to support older workers by allowing their participation in the design of personal workload management. Cahalin (2009) identifies high job strain throughout work life as a prominent risk factor for health problems and early retirement among ageing workers. While these and other authors suggest redesign of strenuous jobs and technology, in particular for older workers. Other authors although (e.g; Allvin, Aronsson et. al, 2006; . Cropley & Zijlstra, 2011 Theorell, 2009) conclude that workload reduction through job redesign could be hard to achieve because contemporary working life is characterized by increased intensification, with more time pressure, higher requirements for productivity and efficiency, as well as by increased requirements for flexibility and blurred boundaries by work and free time. Cropley (2015) has recently emphasised the need to develop an effecting unwinding ritual after work to cope with contemporary working life and that only 1 in 3 of the workforce adopt effective unwinding to minimise risks to health and wellbeing.

While the tendencies toward increased utility of the workforce are associated with obvious short-term advantages for the employing organizations, greater strategic workforce planning is required in relation to the acquisition, retention, development, motivation and deployment of the older workforce by employers (Beames, 2015). If not properly handled, the increased pressure for efficiency may be in conflict with the possibility to retain older workers, potentially effecting organisational performance and sustainability.

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Stimulating innovation through small business and university collaboration

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Keywords: action research, entrepreneurship, innovation, learning

This study is an independent evaluation of the project Creating Competitive Jobs (CCJobs) and summarizes the results and lessons learned from the project and highlight aspects that should be further developed. The overall aim of CCJobs was to create new jobs through mutual exchange between companies and higher education institutions. A basic principle of the CCJobs concept is that researchers at relevant departments at the participating institutions supervise selected company representatives. Moreover, the company representatives are placed at the supervisors' departments during the project period and therefore get the opportunity to become fully immersed by the academic environment. This in turn creates opportunities for collaboration and shared learning that goes beyond traditional knowledge transfer. CCJobs was financed by Interreg and intended to promote regional cooperation in the region. A total of 15 companies and five higher education institutions from both Denmark and Sweden participated.

CCJobs has been evaluated as a case study. The primary data for the case study consisted of 16 interviews and two surveys. Where, a first survey was sent to the company representatives at the beginning of their project and a second survey to both supervisors and company representatives at the end of the project. Furthermore, informal observations on a couple of project activities and discussions with project management were also used as data for the evaluation. The interviews were transcribed, questionnaires were compiled and an overall analysis was conducted of all data.

Generally, the results show that CCJobs was a successful project that created growth for the participating companies and a deepened level of collaboration with universities in the region. So far, the small business and university collaborations has generated; (1) Five new products by four different companies, (2) five new jobs in four different companies, (3) five companies has made applications with researchers for research and development funding whom has led to substantial grants, (4) creation of two new companies, (5) developed business models in existing companies and plans for expansion, (6) companies with a more cooperative direction, (7) deepened knowledge and competitiveness by laboratory research and measurements, (8) around 10 scientific publications.

The success of CCJobs can be explained by that the project provided good opportunities for interaction and learning, with an active selection of challenging subprojects and provided a financial supplement which freed idea time and allowed risk taking. But of course, despite this, the concept can still be improved, based on the evaluation; we conclude that the following areas should be considered for improvement, we also give suggestions on how this could be achieved:

- Timing (project conducted during holidays). Start the project after the holidays.
- Joint inquiry of mutual concern. Ensure a trust‐based cooperation that will benefit both practitioners on the company and the supervisors at the institution.
- Make sure that both parts agree on the nature of their common work process to ensure that the expectations of the various parties' efforts are realistic.
- Tedious administration. Simplify procedures and adapt the organization for collaboration. This applies mainly to the university, state and federal (EU) level, where the latter two can be difficult to influence.
- The supervisor giving the project a low priority. Integrate project in the supervisors' other activities such as in teaching, research and seminars in order to increase the incentive.
- Participating departments with a micro-culture that has a weak social dimension (attitude and natural meeting places).
- Pay attention not only to academic excellence but also to collaboration skills in the selection of the participating departments at the institutions.
- Management of failed collaboration. Review the possibilities to finish subprojects prematurely if the cooperation fails. This could take the form of a conditional start-up phase where the project participants have one or two months to get started and to establish the forms of their cooperation.

Stress hormones in the hair: A new method for investigation of stress and work-load.

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Accumulated levels of stress-hormones affect several psychological and bodily processes and might have detrimental effects on human health, well-being and performance. In the current pilot-study we investigated a possible association between the levels of stress-hormones cortisone and cortisol in the hair (HCC) and students stress levels, recovery from stress and self-evaluated health. There were no significant correlations between HCC-levels and experienced student stress, need for recovery or self-evaluated health status. There were, however, a significant correlation between HCC-levels and items from the stress scale related to perceived future work insecurity and low availability of teachers and professors.

Key words: Stress, recovery, self-evaluated health, hair cortisol, hair cortisone

1.0 Introduction

Experienced stress, and especially chronic stress, is related to health and sickness most probably through the detrimental effects of the stress hormones. Among these hormones are cortisol and cortisone and several investigations have shown that they influence the immune system, metabolism, hypertension and sleeping patterns. They are also associated with depression, chronic fatigue, migraines and arthritis. Thus, stress hormones seem to affect a number of bodily processes and, therefore, could be an important biomarker for several health conditions. Cortisol has normally been measured in urine, blood or saliva presenting a here-and-now picture of the hormone levels. Long-term measurements using these techniques are complicated, expensive and time-consuming. However, in the last years, a new promising method has been increasingly used, measurements of cortisol concentrations in the hair (HCC). Since the human hair grows approximately 1 cm per month, this new measure reveals accumulated levels of cortisol over months.

In the current paper we present some results from at pilot study on a student sample aimed at showing possible associations between student stress, need for recovery, self-evaluated health and concentrations of cortisol and cortisone in the hair.

2.0 Methods

2.1 Subjects

The subjects were voluntarily recruited from a population of undergraduate students in psychology (N=65; 43 women and 22 men). Mean age of the male and female sample was 21.2 years (SD=2.2) and 20.1 (SD= 2.1), respectively.

2.2. Hair cortisol

Hair samples were taken from the back of the skull (vertex right side) and kept dark. Mean weigh of the hair samples were 47.5 mg (SD=9.1). The length of the hair samples were 3 cm, i.e. measurement of the mean levels of HCC in 3 months.

Hair cortisol and cortisone concentrations (HCC) were measured using an automated online SPE LC-MS3 method (Quinete et al. 2015). The analyses were carried out at the Uniklinik, RWTH, University of Achen.

Mean cortisone values for men and women were14.4 pg/mg (SD=10.9) and 14.4 pg/mg (SD=12.8), and mean cortisol values for men and women were 7.2 pg/mg (SD=5.8) and 7.6 pg/mg (SD=6.7), respectively. There were no significant gender differences in HCC.

Figure 1 shows how cortisol might be transported into the hair via sweat, sebum for the bloodstream.

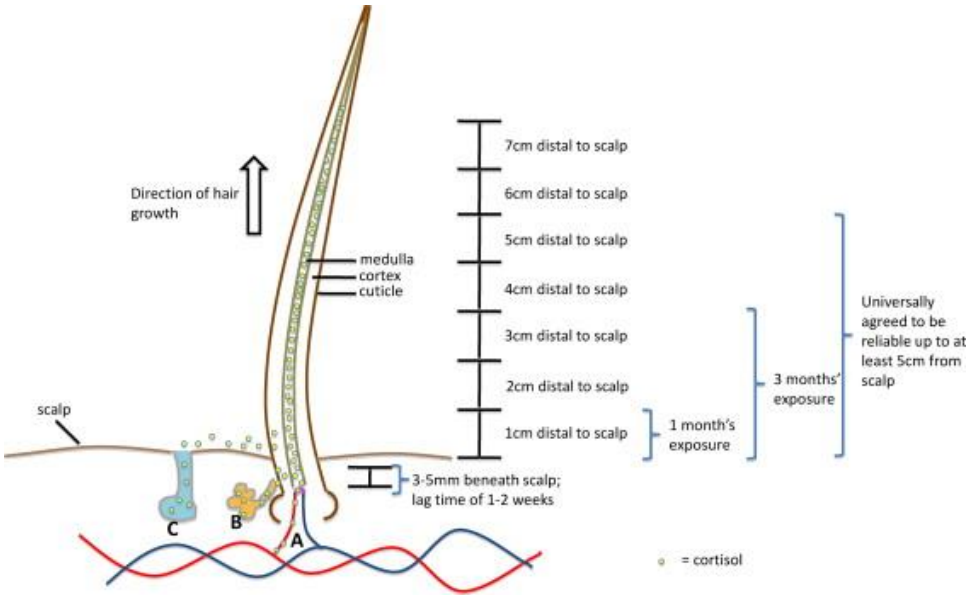

Figure 1. Possible ways of transportation of cortisol into the hair. A: Blood-stream, B: Sebum, C = Sweat. Adapted from Russel et al. (2012).

2.3Questionnaires

Experienced level of stress was measured using the *Student Stress Survesy (SSS)*. This 25-item scale consists of two subscales scales where the subjects rate the Intensity of stressors (1-9) and Frequency of stressors (0-9). Examples of items: *"..relating to new people, planning the study, large curriculum, future work possibilities, grade pressure, concentration problems, availability of teachers and professors, deadlines etc."* The SSS was developed from the Spielberger's JSS by Håseth (2008).

Recovery from stress was assessed using the *Need for Recovery Scale* (Sluiter, 1999). This scale consists of 11 items with Yes/No response alternatives. Examples of some items: *I find it hard to relax at the end of a working day - At the end of a working day I am really feeling worn-out - My job causes me to feel rather exhausted at the end of a working day.* The items (Yes) are summated to yield one single index. Higher values refer to a higher need for recovery. The Need for Recovery scale was originally developed for work-setting and has been shown to predict long term health effects (Sluiter et al., 2003).

Self-evaluated health-status was assessed by asking the subjects two questions: 1) *How would you rate your health status at present* (1-very good: 5-very poor) and *How would you rate your health status in general*? (1=very good; 5-very poor). Self-rating of health status is frequently used in population studies and are shown to be appropriate measurements (Eriksson et al., 2001).

2.4. Statistical analyses

In addition to descriptive analyses, associations between HCC and scores on the SSS, subjective health status and the Need for Recovery Scale were analysed with bivariate correlations.

3.0 Results

Table 1 shows the correlations betwee stress hormones in the hair and scores on the questionnaires.

Table 1. Bivariate correlations between hair-cortisone, hair-cortisol and SSS-Intensity, SSS-Frequency, Need for Recovery, and Self-evaluated health status.

	Cortisone	**Cortisol**
SSS Intensity	.02	-.04
SSS Frequency	.06	.08
Stress recovery	-.22	-.31*
Self-evaluated health status – at present	.09	.01
Self-evaluated health status – in general	.10	.03

N=65; * = p<.05.

There was a significant negative correlation between HCC and Need for Recovery, but no significant correlations between HCC and the other variables.

Table 2. Bivariate correlations between the stress-scales, Need for recovery and Self-evaluated health status.

	SSS-Intensity	**SSS-Frequency**
Recovery	.36*	.06
Self-evaluated health status – at present	.04	-.35*
Self-evaluated health status – in generally	.10	-.07

N=65; *=p<.05.

There was a significant positive correlation between recovery and reported intensity of the Student Stress Survey; the higher the intensity of stressors, the longer recovery time. However, there was no significant correlation between recovery and frequency of the same stressors. We also found a significant negative correlation between reported frequency of stressors and subjective health status here-and-now. There were no significant correlations for the other variables.

There were, however, interesting correlations between some of the items in SSS and stress-hormones.

Table 3. Bivariate correlations between hair-cortisone, hair-cortisol and selected items from the SSS-Intensity and SSS-Frequency

	Cortisone	**Cortisol**
Worrying about future jobs - SSS Intensity	.07	.09
Worrying about future jobs - SSS Frequency	.25*	.18
Availability of teachers and professors – SSS Intensity	.24	.21
Availability of teachers and professors – SSS Frequency	.52**	.25*

N=65; ** = p<.01, * p<.05

There were significant correlations between HCC-values and items related to perceived future work unsecurity and items related to how often the students experienced low availability of their teachers and professors.

4.0 Discussion

There were no significant association between HCC and scores on the Student Stress Survey and self-evaluated health status. Since HCC is a measurement of chronic stress (accumulated levels over the preceding three months in this study) the results were not surprising. There is generally a low correlation between instruments assessing short-term and long-term stress.

The negative association between HCC and recovery from stress is interesting and could point to a relationship between stress-hormones and sports. Skoluda et al. (2010) reported significantly elevated hair-cortisol levels among amateur athletes, and especially endurance sports. Norwegian students are generally engaged in all kinds of sports and athletic activities, and Lillehammer (from where the students were recruited) is known as an athletic sport town (skiing, cycling etc.). Thus, our student sample could have elevated HCC levels due to high athletic activity influencing the recovery rate. Physical activity is also positively related to general health and this relationship is well known (Pate et al. 1996). However, it should be noted that the Need for Recovery Scale was developed for other settings than student settings.

Although we did not find an association between HCC and the total scores of the SSS-scale (table 3), there were significant correlations between items reflecting cognitive stressors: Worrying about future jobs and perceived availability of teachers and professors. The more worrying and the less availability, the higher the values of cortisone and cortisol. Thus, psychological factors such as frustration and anxiety provoking factors could elicit neuroendocrine stress response. This suggestion is also supported by experimental stress research. For instance, Gaab et al. (2005) using the Trier Social Stress Test to assess the effect of anticipatory cognitive appraisal on cortisol response, found that 35% of the variance of salivatory cortisol resonse could be explained by this cognitive factor. Our findings should, therefore, be further tested in more elaborate designs and using other stress scales the SSS.

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Responsiveness and Reliability of Selected Neuromuscular Fatigue Measures for Workplace Use

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Fatigue is related to production errors and is a possible precursor to the development of work-related musculoskeletal disorders. However, there is limited information on the reliability and sensitivity of fatigue measures and the effect of diurnal fluctuations. This study reports on the evaluation of four measures. Ratings of perceived fatigue and action tremor were highly reliable and responsive during an intermittent isometric handgrip contraction. However, action tremor demonstrated a circadian effect. Preliminary evidence suggests that these measures should be considered for inclusion in a test battery but additional analytical consideration might be required when interpreting daylong responses of action tremor.
Keywords: Neuromuscular Fatigue, Fatigue Measurement, Circadian Rhythm

1. Introduction

Fatigue has been cited as an intermediary factor between poor ergonomics and production errors (Kolus et al., 2014) and as a possible precursor to the development of work-related musculoskeletal disorders (Nussbaum 2001). By understanding the temporal pattern of fatigue and its relationships with disorder risks and work performance, fatigue may thus be a useful risk indicator as well as a design and evaluation tool. However, there is limited information on the reliability, sensitivity, and utility of fatigue measures as part of a test battery for field collections. Low reliability or sensitivity could lead to null findings in such fatigue studies. This study reports on an evaluation of four measurement tools, suggested by a group of expert fatigue researchers for their perceived validity and practicality. The aim of this study was to: (1) evaluate the reliability and compare the sensitivity of selected fatigue measures, and (2) investigate the daylong reliability (i.e., the possible effects of diurnal changes) of these selected measures.

2. Methods

2.1. Participants

Sixteen healthy university-aged students (8 males, 8 females, mean age = 24 years, mean height = 171.6 cm, mean weight = 70.7 kg) who met all screening criteria were recruited to participate. Two participants (1 male, 1 female) were left hand dominant. All participants provided informed consent for the experimental procedures and associated risks prior to the experimental session.

2.2. Test battery of fatigue measures

Rating of perceived fatigue (VAS Scale). Perception of fatigue was obtained using a 10-cm visual analog digital scale. Perceived fatigue was expressed as a value between 0 (no fatigue at all) and 100 (complete exhaustion).

Maximum voluntary contraction (MVC). Participants exerted maximum voluntary handgrip forces with a handgrip dynamometer (Medical Research Ltd., Leeds, UK). With verbal encouragement, participants exerted a ramped maximum contraction for 5 seconds. The middle 3-seconds was windowed and values were averaged.

Muscle activity. Electromyography was recorded using bipolar surface electrodes (Ag-AgCl electrodes, Ambu Blue Sensor N, Denmark), placed on the belly of the extensor carpi radialis (ECR) and flexor carpi radialis (FCR). Signals were amplified and sampled at 2048 Hz and collected during a 30% MVC test contraction. Root mean square (RMS) amplitude was calculated at 1-second intervals and averaged over the middle 15 seconds.

Action tremor. A tri-axial accelerometer (ADXL335, Analog Devices, Inc., Norwood, MA, USA) was attached on the dorsum of the dominant hand. Action tremor signals were bandpass filtered (Butterworth, 2nd order) between 1 and 20 Hz. Amplitude of the signal was calculated as the averaged RMS over the middle 15-seconds of data during the 30% MVC test contraction.

2.3. Protocol

Reliability, sensitivity, and circadian assessments were conducted on four separate days. On the first day (reliability test), participants were asked to perform a test battery at 5-minute intervals for a total of 13 trials. On the second day (sensitivity test), test batteries were collected at 1-minute intervals during a fatiguing intermittent handgrip exercise (i.e., mean amplitude = 30% MVC, duty cycle = 50%, cycle time = 6 seconds). These work variables were in the same order of magnitude as previous studies, both in terms of cycle time and duty cycle, and are within the force magnitude relevant to workplace fatigue effects. Participants performed the intermittent fatiguing protocol until volitional fatigue or until an observable degradation of performance. The final two days were dedicated to measuring diurnal effects, between 08:00 and 20:00 hrs. Circadian data was collected at 2-hour intervals during a traditional time-of-day protocol representing a normal working day.

Participants were seated at a desk facing a computer monitor that displayed visual feedback of handgrip force (LabView, National Instruments Corporation, Austin, TX). Auditory feedback was provided to indicate contraction and relaxation periods during the fatiguing protocol. All tests were executed with the dominant hand.

2.4. Statistical analysis

Two-way random-effects model intraclass correlation coefficient analysis was performed to measure the degree of consistency for each measure. An ICC score less than 0.20 indicates poor agreement, between 0.21 and 0.40 indicates fair agreement, between 0.41 and 0.60 reflects moderate agreement, between 0.61 and 0.80 reflects strong agreement, and scores greater than 0.80 indicates almost perfect agreement (Bain et al., 1993).

To evaluate sensitivity, test battery measures were plotted over time, normalized, and fitted with a logarithmic regression function. The slopes were then used as the dependent measure in a mixed-model analysis to compare battery measures during the fatiguing protocol. To ensure equitable comparisons, the magnitudes of slopes were compared in the direction of increasing fatigue. Tukey post-hoc tests determined any statistical differences between measures if a significant main effect was identified.

When evaluating diurnal effects, measurement values were standardized for each participant across both testing days and averaged at each time period. A z score of zero was indicative of the mesor (or mean level) of a circadian rhythm and scores above or below reflect a higher or lower than average physiological response. Data was then evaluated for normality by plotting data as a histogram, drawing Q-Q plots, and the Shapiro-Wilk test. To detect the rhythmicity of circadian rhythms, cosinor analysis, which fits cosine curves using least square methods, estimated the pattern of a smooth rhythm. The resulting outputs for each time point are: mesor, amplitude, and acrophase. Zero-amplitude testing was performed to test the null hypothesis that the amplitude is zero (i.e., there is no rhythm).

All statistical analyses, unless otherwise stated, were conducted using Statistical Analysis Software (Version 9.3, SAS Institute Inc., Cary, NC, USA) at an alpha level of 0.05.

3. Results

Mean intraclass correlation coefficient scores for test battery measures (Figure 1A) ranged between 0.666 and 0.834. Almost perfect agreement was observed in action tremor (ICC = 0.834) and perceived fatigue (ICC = 0.808). Strong agreement was found with MVC (ICC = 0.666) and EMG amplitude of FCR (ICC = 0.768) and ECR (ICC = 0.734).

Mean endurance time to volitional fatigue was 15.31 minutes. The mean rate of response ranged from 0.341 to 1.459 normalized units/Δtime (Figure 1B). Action tremor was statistically different from MVC ($p = 0.001$) and EMG amplitudes of the FCR ($p = 0.001$) and ECR ($p = 0.001$). The rate of response for perceived fatigue was statistically quicker than MVC ($p = 0.045$) and EMG ECR ($p = 0.014$).

Measures were analyzed for their rhythmicity (Table 1). Action tremor amplitude demonstrated rhythmicity over the 12-hour period. The acrophase occurred at 18:56 hrs.

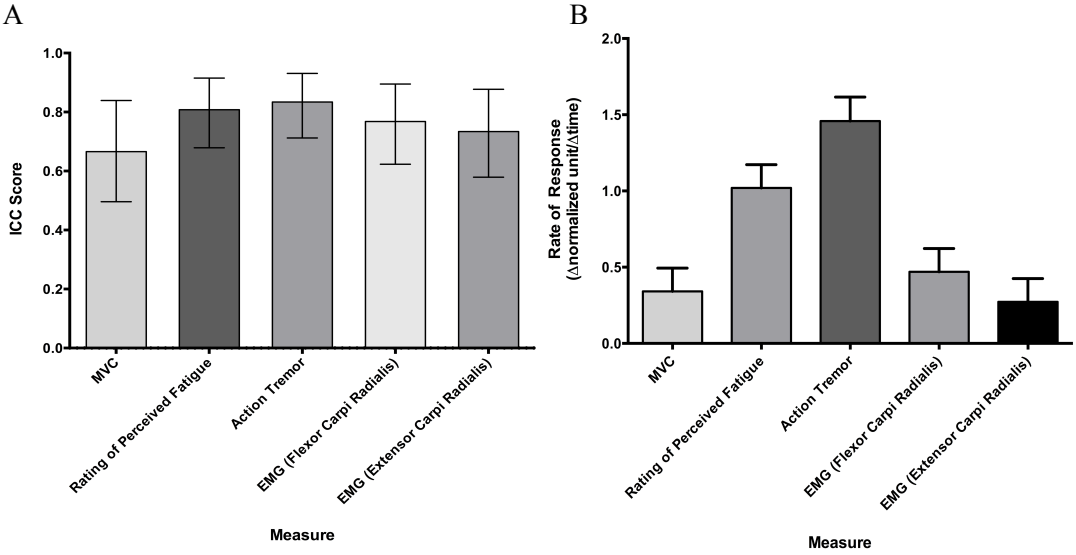

Figure 1. A: Mean intraclass correlation (ICC) scores for five fatigue measures. B: Rate of response of test battery measures.

Table 1. Single cosinor analysis of fatigue measures.

Measure	Mesor (Z-Value)	Amplitude (Z-Value)	Acrophase (Hr:Min)	Zero-Amplitude Test	% Rhythm
MVC	0.040	0.134	07:12	$F(2,4) = 1.887$; $p = 0.265$	10.6
RPF	0.000	0.000	-	$F(2,4) = 0.000$; $p = 1.000$	0.0
EMG FCR RMS	-0.004	0.182	15:56	$F(2,4) = 6.034$; $p = 0.063$	53.4
EMG ECR RMS	0.000	0.193	07:24	$F(2,4) = 3.367$; $p = 0.139$	34.8
Action Tremor	-0.121	0.381	18:56	$F(2,4) = 10.715$; $p = 0.026$ **	63.0

** = Statistically significant zero-amplitude test at $\alpha = 0.05$. Mesor = Midline Estimating Statistic of Rhythm; % Rhythm = Proportion of Overall Variance Accounted for by Fitted Model.

4. Discussion

4.1. General discussion

Perceived fatigue measured with a visual analog scale was highly repeatable, demonstrating an ICC value of 0.808 in test-retest situations. Five-minute rest period was introduced to minimize fatigue but repeated trials led to increased perceived fatigue towards the end of the test session. Test-retest reliability assessments have been performed on perceived fatigue with varying degree of reliability, ranging between 0.60 and 0.97. At a comparable force level of 20% MVC, Oskouei et al. (2013) observed a single measure ICC(2,1) score of 0.716 for the FCR, which approximates the reliability observed in this study (ICC = 0.768). Although extensors were excluded from Oskouei et al.'s (2013) study, the average single measures ICC value for all studied forearm muscles and at all contraction levels was 0.666, which can be interpreted as strong agreement. Both FCR and ECR muscles in this study fall within this ICC category. Action tremor demonstrated almost perfect agreement. However, to the authors' knowledge, there is very limited information on the responsiveness and reliability of action tremor.

Of the selected fatigue measures, action tremor and rating of perceived fatigue were highly responsive, with rates of responses greater than one normalized unit per test battery. These measures were statistically different from the least responsive measures. Tremor has been shown to increase as a result of muscular contraction and after a fatiguing task. For instance, Leyk and colleagues (2006) observed a three-fold impairment of hand-steadiness with an exhaustive lift and hold task.

Additionally, with action tremor, the observed nadir of the diurnal oscillatory function occurred at 08:00 hrs and an acrophase at 18:56 hrs. Action tremor measurement values were below the daily average during the morning (08:00 – 10:00 hrs), above average during the afternoon (12:00 – 18:00 hrs), and decreased to the daily average, or below average, in mid-evening (20:00 hrs). Although there is sparse information on the diurnal changes associated with action tremor, diurnal rhythms of physiological tremor, particularly under constant routine conditions, have been previously reported. According to Eagles and colleagues (1955), an increase in tremor amplitude occurred during the afternoon and early evening, decreasing to a lower level of tremor in the evening. The reduction in tremor may be attributed to increased muscular relaxation as a response to mental exhaustion or tiredness (Eagles et al., 1955). Action tremor responses in this study generally agreed with this diurnal pattern. Rating of perceived fatigue, maximum voluntary contractions, and muscle activity, on the other hand, did not demonstrate a significant circadian rhythm.

4.2. Selection of measures based on assessments

The current study provides evidence for fatigue measures and their estimates of reliability and responsiveness. These measures were highly recognized by an expert group of researchers as potentially useful in measuring fatigue in occupational settings and were measures based on strong theory. Selection of fatigue measures, however, does not rely solely on one criterion, but of the collective assessments.

With this in mind, we found action tremor to be reliable and responsive to intermittent isometric handgrip contractions at 30% MVC. However, action tremor may be susceptible to diurnal effects. There is some conflicting evidence to the aetiology of tremor. For instance, tremor may be consequence of a central 8- to 12- Hz oscillatory mechanism derived from the inferior olive, central oscillations originating at the thalamus, stretch-reflex servo-loop, and cardioballistic oscillations. Unlike physiological resting or postural tremor, action tremor during an isometric contraction minimizes signal contamination (McAuley et al., 1997). It has been speculated that action tremor might involve Renshaw cell inhibition, motor unit recruitment and firing, and changes in metabolite concentration.

Perceived fatigue using a visual analog scale similarly appeared to be reliable and responsive. Furthermore, we did not observe diurnal fluctuations. There are many advantages of

using a visual analog scale to measure fatigue. It is simple, easy, and quick to administer, is strongly related to fatigue and reduced work capacity, and reflects central mechanisms.

One major limitation of this study is the use of a single exercise protocol to assess responsiveness of the fatigue measures. Fatigue responses, and therefore the method to measure fatigue, are task-dependent and might be influenced by physical exposure parameters, including duty cycle and cycle time, intensity, type and speed of contraction, and muscle groups involved. As a preliminary step to assess sensitivity, this study provides information on one aspect of responsiveness using mean force amplitude relevant to occupation and fatigue effects and duty cycle and cycle time similar to previous studies. Further studies are required to assess the sensitivity of these measures under different exercise profiles and in a less well-controlled workplace setting.

5. Conclusion

Devising a set of practical fatigue measures is a step towards detecting and documenting fatigue at work. The current study evaluated four measures, selected for their perceived validity and practicality for field collection. Action tremor during a test contraction, and perceived fatigue assessed by a visual analog scale, were found to be highly reliable and most responsive. However, action tremor appeared to be susceptible to diurnal effects and might require additional analytical considerations when interpreting daylong responses. The findings suggest that these two measures should be considered, along with other measures of interest, as part of a test battery when measuring fatigue.

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Reliability in ergonomic risk assessments by observation

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There is a need for reliable and time efficient methods to be used by ergonomists in occupational health services. This paper presents the agreement (1) between twelve ergonomists who made risk assessment of 10 video-recorded work tasks, first without any specific method, and then by using the OCRA checklist, and (2) between 6 different observation methods, rated carefully, in consensus, by three expert ergonomists. The inter-rater reliabilities of the over-all risk levels (own and OCRA) showed linearly weighted kappas of about 0.4, i.e. between fair and moderate agreement. Also in the consensus assessments, the different methods showed a considerable variation of identified high risk tasks. The results illustrate that it is hard to obtain reliable risk level assessments, and it may appropriate to, to a larger degree, combine observations with validated methods of direct measurements.

Keywords: Agreement, Observation, Risk assessment method, Biomechanical exposures

1. Introduction

The Swedish Work Environment Authority has recently increased the demands on ergonomic risk assessments. These assessments are usually made by ergonomists in occupational health services (OHS). Although they are many observational methods that may be used (Takala, et al. 2010), the ergonomists often do risk assessment by sole observation, based on his/her own knowledge and experience, without the use of any specific method. Evidently factors that affect obtained the risk level are: if a method is used - which method, who is doing the assessment, how long and which period of the full work day is assessed.

This study is part of a larger on-going project, the OBS-project, with the overall purpose to evaluate six observational methods (Occupational Repetitive Actions checklist (OCRA), Quick Exposure Checklist (QEC), Strain Index (SI), Assessment of Repetitive Tasks (ART), Hand Arm Risk-assessment Method (HARM), and Model for assessment of repetitive work by the Swedish Work Environment Authority (SWEA) for assessment of biomechanical exposures of repetitive work in respect of validity, reliability and usability, as well as provide information on which of the methods are best suited for practitioners in risk assessment of repetitive work. The project includes also the ergonomists' "own" assessments (without any specific method) of the risk of developing musculoskeletal disorders.

The purpose of this paper is to summarise the found reliability of "own" assessments, OCRA checklist assessments, and between methods, and to discuss reliability difficulties within observational risk assessments.

2. Methods

Twelve OHS-ergonomists, all women, with more than 5 years of experience of general ergonomic risk assessments, first made assessments (green, yellow, red; over-all risk, and for 8 body-parts) of 10 video-recorded (2-6 minutes) work tasks (supermarket work, meat cutting and packing, engine assembly, cleaning, post sorting and hairdressing). Video sequences of two or three camera angles were synchronized and showed together. For each work task, the ergonomists were given data of the work task length, pause- and rests-schedules, weights of handled goods, physical factors, and the employees' ratings of discomfort, work demands and control. They could pause or repeat the playback as they needed. The maximum time per video was 20 minutes. This abstract also includes the ergonomists' OCRA checklist assessments.

An expert group of three ergonomists, very carefully, made consensus assessments of all methods on the ten videos.

Linearly weighted Kappas (Warrens, 2013) were computed for the inter-method reliability, and by averaging (Light, 1971) the pairwise Kappas, for the ergonomists own assessments and for the OCRA assessments.

The ergonomist could pause or repeat the playback as she needed, but the maximum allocated time per work task assessment was 20 minutes.

3. Results

Of the 960 own risk assessments (12 ergonomists, 8 body regions, 10 work tasks) of the separate body regions, 36% were green, 46% yellow and 18% red. Of the 120 over-all risk assessments, 14% were green, 50% yellow and 36% red. The consistency among observers differed markedly between the tasks, both in the own and the OCRA risk assessments.

For the own ratings, in three work tasks all three risk categories were represented, whereas in one task all ergonomists rated the over-all risk equally (green). The average relative agreement of the own ratings was 48% for the body regions, and 40% for the over-all risk assessments. The averaged linearly weighted kappas were 0.23 and 0.40, respectively. The lowest weighted kappa, 0.12, was seen for the right arm/elbow.

For OCRA, the over-all risk level, had a relative agreement of 39%, and a linearly weighted kappa of 0.41. The weighted kappa of the seven dimensions, ranged from 0.17 (Posture) to 0.48 (Duration). From the expert group consensus assessments of the 10 videos, the number of red risk level ratings ranged from 1 (HARM) to 8 (SI). When methods assessing the same body regions were compared pairwise, no pairs showed complete agreement. The two highest, 'substantial agreements' (according to Landis and Koch's, 1977, recommendations for interpretation) were found, between SWEA and QEC (general, Linear weighted kappa, 0.71), and between ART and OCRA (upper extremities, 0.74). The lowest 'slight agreements' were found between HARM-QEC (upper extremity, 0.10), OCRA-QEC (upper extremity, 0.17), and SI-QEC (hand/wrist, 0.14).

4. Discussion

The inter-rater reliabilities of the over-all risk levels (own and OCRA) showed linearly weighted kappas of about 0.4, which at the border between fair and moderate according to Landis and Koch's (1977) table for interpretation of kappa. Several specific body parts (own), and dimension (OCRA), the weighted kappa was below 0.4, in the slight to fair range. In the worst case, the weighted kappa was 0.12, which is merely above what could be expected by chance.

In comparison to observing and performing risk assessments of the tasks at the workplace, these assessments from video-recordings are a bit different. But there were no alternative to video-recording, since the different ergonomists should see the same thing. To facilitate observation of different joint angles, the recordings were made with two to three cameras of different views, which were laid side by side into one film, which the ergonomists were allowed to pause or repeat the playback as they needed. In real life, with live observation, one may assume that the agreement between ergonomists would decrease, rather than increase, since the ergonomists do not see exactly the same views nor work cycles.

One could expect that when a detailed procedure of assessment is used (as in OCRA), the figures of reliability would increase, but here they were in the same range. Also, in the consensus assessments, the different methods showed a considerable variation of identified high risk tasks.

4. Conclusion

Taken together, it looks very hard to obtain reliable risk level assessments, and it may be time to, to a larger degree, combine observations with validated methods of direct measurements.

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Reliability of 25 ergonomists' ratings of risks with QEC and RULA

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Work-related musculoskeletal disorders (WMSD's) are still common. In order to identify risks, systematic and feasible assessment methods are needed. The aim of this study was to investigate the inter- and intra-observer reliability of Quick Exposure Check (QEC) and Rapid Upper Limb Assessment (RULA). Twenty-five ergonomists watched video-recordings of five different work tasks, and made ergonomic risk assessments using QEC and RULA. Three weeks after the first risk assessments they made new assessments with both tools. The mean inter-observer reliability was slight, and the intra-observer reliability was fair both for QEC and RULA, measured by Cohen's kappa and linearly weighted kappa.

Keywords: WMSD, Ergonomics, observation method, risk assessment

1. Introduction

Work-related musculoskeletal disorders are still common. In order to identify risk factors, to compare different workstation designs, to prioritise improvements, and to evaluate interventions, systematic and feasible methods are needed. Several observation-based risk assessment methods have been described and suggested in the literature. According to a review of 30 assessment methods (Takala et al. 2010), most of the methods need to be more tested for validity and reliability. There is also a request from the Occupational Health Services (OHS) to obtained time-efficient scientifically tested risk assessment methods (Andersson et al. 2006).

Quick Exposure Check (QEC) and Rapid Upper Limb Assessment (RULA) are two ergonomic risk assessment tools that both have been designed to be useful for ergonomists (David et al., 2008, McAtamney and Corlett, 1993). RULA has shown an association with musculoskeletal disorders in cross-sectional studies.

The methods are, like most of the observation methods, built upon components, as posture and frequency, and handled weight, by a number of questions with 2-4 reply categories. The components are then weighted and summed to a risk-index per body part that are interpreted into 4 exposure categories (or priority levels for intervention): Low, Moderate, High or Very High (for QEC, similar but with other namings for RULA).

2. Objectives

The aim of this study was to investigate the inter- and intra-observer reliability of QEC and RULA, when being used by simultaneously and recently trained professional ergonomists.

3. Methods

Twenty-five ergonomists employed at different OHS in Sweden were informed about the methods theoretical principles and were trained in the practical usage of QEC and RULA, in a two-day course.

Five different work tasks were video-recorded. The work tasks were: instrumentation during surgery in an operating theatre, window replacement, toilet cleaning, sorting post, and

nailing a wooden pallet. The ergonomists watched the five videos and individually made ergonomic risk assessments using the two tools. Three weeks after the course the ergonomists watched the same videos, and made new risk assessments with both tools. For QEC a few questions should be answered by the worker, e.g. about maximal exerted force, and visual demands. In this study the ergonomists were given those answers.

Two parameters were computed as measures of the inter- and intra-rater reliability: Cohen's kappa (Light 1971) and linearly weighted kappa (Fleiss and Cohen 1973), which were both computed as Light suggested by averaging pairwise kappas (inter-rater reliability), and averaging individual test-retest (intra-rater reliability). The kappa values were computed for each exposure question, 7 for QEC, and 16 for RULA.

4. Results

The first time, assessments were obtained complete enough to be included in the analyses from 23 and 25 ergonomists (QEC and RULA), and from the second time 18 and 17.

For the inter-rater-reliability, the average kappa and linearly weighted kappa for all rated questions were for QEC: 0.16 and 0.18; and for RULA: 0.13 and 0.20. For the intra-rater-reliability, the average kappa and linearly weighted kappa for all rated questions were for QEC: 0.26 and 0.29; and for RULA: 0.22 and 0.31. The wrist questions ratings showed low reliability in both methods.

5. Discussion

Cohen's kappa is often used, while the linearly weighted kappa is more comparable between ratings in different number of categories, therefore both were used here.

The average reliability of both methods was lower in this study than what could be expected from previous reports (Takala et al. 2010). According to Landis and Koch's (1977) recommendations (0-0.2 slight, 0.21-0.4 fair, 0.41-0.6 moderate 0.61-0.8 substantial, 0.81-1 almost perfect), the mean inter-reliability was only slight in both methods. One could assume that the level of agreement would be better since the ergonomist just learned the tools – together. The intra-rater-reliability was, as expected somewhat higher, but still only fair. It may be possible to improve these results by increasing the training periods. However, one should also consider to replace observations in components where it is possible (e.g. in the component: is the back neutral, or moderately or excessively flexed?), with direct measurements.

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Key informants' perspectives on barriers and challenges to successful prevention of Musculoskeletal Disorders (MSD) in organizations

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As a part of a larger research project, this study explored key informants' perspectives on barriers and challenges for successful prevention of Musculoskeletal Disorders (MSD) in organizations and possible solutions to overcome these challenges. Key informants (23) were interviewed using semi-structured technique and analyzed using a thematic analysis approach. The results suggest that a lack of strategic and systematic approach to prevent MSD is the major challenge that could potentially jeopardize the success of MSD prevention activities. Innovative approaches to integrate MSD prevention into management systems and practices to improve quality and productivity were argued to be essential in prevention MSD.

Keywords: Musculoskeletal disorders, management systems, innovation, integration, productivity

1. Introduction

Musculoskeletal disorders (MSD) related to work have a high personal, firm and societal burden. It is a challenge for organizations to prevent them. The high prevalence of MSD within workplaces may be partially due to the fact that MSD prevention activities are often disconnected from broader management frameworks, such as management systems. The elements and the structure of these management frameworks allow organizations to systematically improve several aspects of organizational concerns including quality, environment, and health and safety (Yazdani et al., 2015). The purpose of this study was to better understand the key informants' experiences, perceptions, and perspectives on prevention of MSD and their links to three main elements of management systems: management commitment, training, and worker participation. Key informants include experienced consultants, managers, researchers, union representatives, and policy makers who were actively involved in the area of health, safety, and MSD prevention.

2. Methods

Key informants (31) were selected using personal contacts and a snowball technique and recruited to participate in this study. A key informant is an individual that can be called as an expert source of information (Marshal, 1996). Semi-structured interviews were conducted, digitally recorded, and then transcribed verbatim. Most of the interviews were conducted by phone and the language of the

interviews was in English. Interviews typically lasted 45-60 minutes. A qualitative data analysis software package (NVIVO™ Version 10.0) was used to store, organize and help analyze the data. A thematic analysis approach (Braun & Clarke, 2006) was used to code and analyze the data.

3. Results

In total, 23 individuals agreed to participate in this study. This included seven consultants from Health and Safety (H&S), ergonomics, management systems; five senior H&S managers; five senior researchers in the area of H&S, ergonomics, and management; three representatives from organized labour (unions); and three policy makers from policy-making organizations. The participants were located in the Canadian provinces of Ontario, Quebec, and British Columbia, the United States of America, and the Netherlands.

The key informants said that besides the lack of human and financial resources, lack of innovative approaches to measure some of the indirect costs of MSD problems is a significant challenge for organizations. Another challenge was said to be the lack of practical tools to quantify the return on investment for MSD prevention activities. The participants consistently argued that the investment on MSD prevention is not being seen and communicated as an investment to improve efficiency, productivity, and quality. Moreover, as it was noted by key informants, MSD prevention initiatives have always been seen as reactive and practitioners including ergonomists have been considered as reactive “problem solvers”. Work-related causes of MSD problems were discussed as one of the challenges to recognizing these disorders and to convince management about investing, especially where the management may not believe that the causes of MSD problems are work-related. With respect to MSD risk factors, psychosocial factors and how they contribute to development of MSD was noted as one of the challenges for the identification and evaluation of MSD risk factors.

Participants said that a challenge is to define the responsibilities of managing MSD prevention. Should the responsibility be taken by ergonomists, or health and safety committees, or special committees? Or should it be incorporated into other organizational practices? This was mentioned as a key question in the development of prevention strategies by organizations. A best practice approach could significantly impact the sustainability and success of MSD prevention activities. Other challenges for successful prevention of MSD were stated to be: lack of appropriate communication, training and awareness, and ergonomics education for engineers in post-secondary education.

4. Conclusion

This study found that lack of strategic and systematic approach to prevent MSD is the major challenge that could potentially jeopardize the success of MSD prevention activities. Innovative approaches to integrate MSD prevention into a broader framework such as management system and linking it to approaches used by organizations to improve quality and productivity were suggested to be needed to prevent MSD. Future research is needed to develop, implement and evaluate practices, tools and approaches aiming at incorporating MSD prevention into broader organization system frameworks.

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How do organizations address Musculoskeletal Disorders (MSD) prevention within their management system framework?

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The purpose of this study was to document the techniques and approaches used by companies in the manufacturing sector to address Musculoskeletal Disorder (MSD) hazards and how they do or do not integrate these into their health and safety or management systems. A multiple case study was conducted using a qualitative approach. Semi-structured interviews with stakeholders within two manufacturing plants of a corporation, document and record analysis, and workplace site visits were used to collect data for this study. The results suggest that integration of MSD prevention into management systems could benefit prevention through it receiving adequate attention, using existing resources, increasing management support and buy-in, and improving sustainability.

Keywords: Musculoskeletal disorders, management systems, integration, management support, sustainability

1. Introduction

There are a multiple approaches, techniques and programs at the departmental and organizational levels to prevent occupational injuries and workplace accidents. The approaches to prevent Musculoskeletal Disorders (MSD) are rarely linked to broader management system frameworks. Several MSD prevention approaches have been developed and published by researchers, practitioners, and organizations around the world. A recent study conducted by Yazdani et al (2015), assessing the compatibility of Participatory Ergonomics (PE) programs with a management system for health and safety, suggested that irrespective to the strength of PE, it doesn't match business process and practices (Yazdani et al., 2015). We wondered what approaches organizations implement to prevent MSD. As a part of a larger research project, the purpose of the present study was to document the techniques and approaches used by organizations in the manufacturing sector to address MSD hazards and how they do or do not integrate these into their H&S or management systems.

2. Methods

Two plants were recruited from a multi-plant corporation in the manufacturing sector. A qualitative approach was utilized including an interview study, document and records analysis, and workplace site

visits and observations. These multiple approaches allowed a better understanding of how companies address MSD hazards in practice.

Semi-structured interviews were conducted in person. Several stakeholders including the labour co-chair of the Joint H&S Committee (JHSC), H&S coordinator (management co-chair of the JHSC), Human Resources manager, maintenance manager, production engineer, production manager, quality manager, and two workers (an operator and a team leader) were recruited for the interview phase. A qualitative computer software package (NVIVO^{TM} Version 10.0) was used to help store, organize and analyze the data. A thematic analysis approach (Braun & Clarke, 2006) was used to code and analyze the data.

The documents and records were analyzed in order to gain a better understanding of the processes involved in managing H&S and MSD hazards within each plant. A content analysis approach was used in the analysis of the data from the documents and records.

In addition, multiple work areas were observed to study the extent and nature of any changes implemented to improve them. Informal face-to-face conversations with workers were held in both plants to explore workers' involvement in prevention activities.

3. Results

The results showed that, although the corporation mandates a proactive approach to dealing with health and safety hazards in its plants, the management of health and safety in these two plants was more reactive rather than proactive. The case studies showed that two participating plants within the same corporation implemented an Occupational Health and Safety Management System (OHSMS) and an ergonomic program in different ways. The implementation and the success of these programs were primary dependent on the level of management commitment and support. The plants' management commitment towards H&S and MSD prevention when it comes to competing priorities, such as production, was said to be not very positive.

The results of the interviews and document analysis showed that despite some successes, implementing parallel programs for MSD prevention and management of health and safety did not result in a sustainable proactive approach to prevent MSD. Instead this separation caused several barriers and challenges from resource allocation, to hazard identification and risk assessment, to increasing bureaucracy and even more isolation of MSD prevention from the organization's overall business structure. The results of this study revealed that sporadic initiatives to incorporate MSD prevention into other business drivers, led by a quality manager and an engineering manager, resulted in better addressing MSD hazards during the design process, installation, and operation. These approaches were said to get better management buy-in to invest in MSD prevention, increase workers' participation, improve communication, increase awareness, all of which which lead to better prevention of MSD and a safer workplace.

Strong management commitment and effective worker participation were seen as essential and crucial in order to implement any changes in their organizations. Incorporating prevention activities into broader management system frameworks and using tools such as Advanced Product Quality Planning (APQP), Failure Mode and Effects Analysis (FMEA), and 5-WHY methodologies were thought to be essential for success.

4. Conclusion

This study provided an insight into the management of health & safety and MSD hazards in two plants in the manufacturing sector in Ontario, Canada. The results of this study suggested that linking MSD hazards to other business drivers such as quality costs would result in getting management attention and to persuading them to invest in MSD prevention activities. More case study research is needed to document organizations' best practices to address MSD hazards within H&S and other management frameworks.

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Hypotheses on causation and latency of neck and shoulder pain in low-level effort jobs

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Whole-day recordings of neck muscle activity (electromyography, EMG) during work were measured on thirty young workers recently examined from technical school. The amount of sustained muscle activity was analyzed for correlation to neck and shoulder pain reported every 3rd-6th month from one year before to two years after the EMG measurement. A positive significant correlation was found 6 months after the EMG measurement, with an increasing correlation with increasing duration of sustained muscle activity. The results create a basis for the hypothesis on a causal relation between sustained muscle activity and pain development.

Keywords: Hypothesis, neck and shoulder pain, sustained muscle activity, EMG, exposure-effect latency

1. Introduction

Neck and shoulder pain has previously been related to continuous muscle activation (Sjøgaard et al., 2000, Hanvold et al., 2013). Østensvik and co-workers (2009) showed in middle aged forest machine operators that periods with low-level muscle activity lasting approximately 8 min or more was positively correlated to neck pain after 1 year.

The aims of this paper are to discuss the risk for neck and shoulder pain related to sustained muscle activation and if there is a possible latency time between 'exposure' and pain in a cohort of young employees.

2. Methods

Fifteen men and 15 women with mean age 22 years (SD 0.9, range 21-24 y), mean height 171 cm (SD 10, range 152-193 cm) and mean weight 65 kg (SD 11, range 44-90 kg) originally sampled from technical schools and which had recently entered working life or university studies were recruited. Participants presented in this cohort were mainly hairdressers, electricians and students. Inclusion criteria were electromyographic (EMG) measurement at time '0' and response on questionnaire (including pain symptoms) one year before, at time '0' and one respective almost two years after as a minimum. Symptom reports on other occasions were not mandatory for inclusion.

The participants were asked to report pain intensity in the neck and shoulders during the last four weeks every 3rd - 6th month (0: none, 1: mild, 2: moderate and 3: severe) and the duration of this pain (1: 1-5, 2:6-10, 3: 11-14 and 4: 15-28 days). A pain severity index was constructed by multiplying intensity and duration (range 0-12).

Full-day recordings of EMG activity in both upper trapezius muscles were collected at time '0' and Root Mean Square processed with a 1.6 seconds sample length. The mean result of left and right trapezius measurement was used in these analyses. Periods of different duration with a continuous muscle activity >0.5% EMG_{max} were collected (periods of >0 (that is >1.6 s),

>2, >4, >6, >8, >10 and >15 min duration) (Veiersted et al., 2013). The per cent of the total recording time with muscle activity with the given minimum duration was used in the analysis.

Correlation between each of the ten pain severity index scores during this observation time and the EMG variables at time '0' were analyzed by Spearman's rho. See Table 1 for significance levels.

3. Results

No significant correlation was found between EMG measurements at time '0' and pain reports at any time, except for pain reported after 6 months (Table 1.). The correlation between muscle activity independent of duration (>0 min) and pain at that time was low and not significant. However, when only including muscle activity with a continuous duration >4 min, a significant correlation to pain after 6 months was observed. A tendency was found for a higher correlation for an increasing demand on the length of periods with continuous muscle activity, with a borderline significance observed also for duration >2min (Table 1).

Table 1. Correlation between trapezius activity and neck/shoulder pain (Spearmans Rho)

Minimum duration of periods >0.5% EMG_{max}	Time (months) between EMG measurement (gray) and pain reports (negative time assignment before and positive after). Sign. correlation: (* p<0.1, * p<0.05, ** p<0.01.									
	-12m (n=30)	-6 m (n=25)	-3 m (n=24)	'0' m (n=30) EMG	+6 m (n=25)	+9 m (n=26)	+12 m (n=30)	+15 m (n=21)	+18 m (n=25)	+21 m (n=30)
>0 min	-0.30(*	-0.15	-0.14	0.08	0.12	0.15	-0.03	0.04	0.16	-0.11
>2 min	-0.15	0.00	0.14	0.14	0.38(*	0.21	0.14	0.17	0.25	-0.01
>4 min	-0.18	0.01	0.17	0.12	0.44*	0.27	0.18	0.19	0.24	0.03
>6 min	-0.12	0.05	0.25	0.17	0.41*	0.29	0.22	0.2	0.32	0.05
>8 min	-0.06	0.10	0.34	0.22	0.46*	0.32	0.24	0.22	0.36(*	0.07
>10 min	-0.04	0.12	0.21	0.22	0.50*	0.30	0.27	0.29	0.35(*	0.10
>15 min	-0.07	0.14	0.3	0.18	0.56**	0.27	0.29	0.24	0.28	0.17

4. Discussion

This paper presents a simple correlation analyses between muscle activity pattern and neck and shoulder pain in a small group of young workers. The analysis is not adjusted for other possible causes or risk factors for neck and shoulder pain, and should therefore be interpreted carefully. However, it may be the background for hypotheses.

With no demand on the duration of muscle activity periods (>0 min) the accumulated length of muscle activity >0.5EMG_{max} may include many short periods (Veiersted et al., 2013). This may be the explanation for a lack of significant correlation to pain compared to the analyses only including periods with continuous muscle activity for 2 minutes or more. A high variability in the muscle activity pattern may prevent the development of pain.

In this cohort of young workers in various occupations an association to neck and shoulder pain was observed for shorter durations of continuous muscle activity, than in the earlier study of middle aged male forest machine operators (Østensvik et al., 2009). The influence of long periods with continuous muscle activity on risk for pain may be different for different ages and 'exposure' patterns. A muscle activity pattern over time that results in long periods with continuous activity, even at low-effort, may enhance pathological changes and pain development in the muscle and adjacent tissues (Sjøgaard et al., 2000).

It is tempting to assume that *the* longer periods with sustained activity measured during work, *the* higher risk for possible local pathological changes in the muscle and thereby incresaed risk for development of neck and shoulder pain. However, these longer periods may occur in parallel with other risk factors for muscle pain, as psychosocial work factors such as role conflicts (Christensen and Knardahl, 2010) or individual factors as perceived (general) muscle tension (Wærsted et al., 2012). Larger studies, or meta-analyses of existing data

material, should be performed to make it possible to adjust for other risk factors than muscle activity pattern.

The time latency between EMG measurement and increased pain report is difficult to interpret, but the findings may indicate a latency time of half a year for neck shoulder pain after an 'exposure' pattern with long periods with sustained muscle activity in a population with young workers in various occupations. However, the workers have 1- 2 years experience in their occupations from school to the EMG measurement, so the 'exposure' time is longer than the 6 months latency.

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Specific risks for musculoskeletal disorders at professional window cleaning

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1. Background

More than a decade ago a major project was started in Sweden addressing the work environment at professional cleaning. In addition to conventional project reports, the essential results from the project were gathered in a homepage "Allt om städ" (www.prevent.se/allt-om-stad/). After the project was finished some specific aspects on professional cleaning were identified that were not addressed in the original project. Thus a new follow up project was initiated. One of the specific tasks studied here was window cleaning. No exact figures are available but there should be several thousand persons in Sweden who have window cleaning as their occupation. In this paper the risks for musculoskeletal disorders (MSD) for this group are in focus.

2. Methods

Some ten window cleaners from three different Swedish towns participated in the study. The subjects and tasks were selected to cover most kinds of environments and cleaning techniques found in Sweden. The cleaners were interviewed about their working conditions and their work was documented by extensive video filming. The films were analysed to identify specific risks for MSD, related to various sub-tasks.

3. Results and discussion

Three specific risky actions were identified.

1. Frequent work with hand/arm above shoulder height
The obvious solution of course is to use a ladder or work bench when possible. However this may detain the work. Outdoors, much window cleaning is performed from a sky lift which offers excellent opportunities to adjust the work height.

2. Frequent work with flexed/deviated wrist
This specially occurs when the wet window is dried with a rubber scraper using a swirling hand movement. However, some cleaners were observed manoeuvring the scrape by light finger movements preserving a straight wrist.

3. Frequent work with extended neck
This deleterious exposure is closely linked to action #1 above and the solutions are mostly the same. However, at one special technique called "water fed pole cleaning", applied at high glass walls where a sky lift is not applicable, this exposure was more marked and static over long times. A possible solution here might be prism glasses.

Long term sleep, fatigue and working conditions at sea: a field study among seafarers

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Keywords: Fatigue, Work environment, Sleep, Seafaring, Working conditions, Field study.

1. Introduction

Working conditions in seafarers are far from optimal where it concerns the possibility of getting sufficient rest and recuperation. Time off between two subsequent work shifts is in many shift systems that are to be found on board usually insufficient to fully recover (e.g. van Leeuwen et al., 2013). Moreover, environmental and other external conditions (e.g. weather, port calls) may even further jeopardize a proper rest. Anecdotal reports frequently imply the presence of a so-called accumulation of fatigue over time (e.g. Wadsworth et al., 2006). Hitherto, however, empirical evidence on the accumulation of fatigue with time at sea is lacking. This will be the first study that specifically aims to answer the question as to whether such an accumulation takes place and furthermore to identify the factors – both individual and environmental - that contribute to fatigue among seafarers.

2. Methods

Two European shipping companies participated with the entire crew of in total 8 ships during their routine operations for periods up to 17 weeks at sea. All participants (n=65) answered a background questionnaire at the start of their voyage containing questions about their general background (age, BMI, etc.), their work and working hours, and about their health and fatigue (sleep need, chronotype, possible stressors etc.). This was followed by a weekly questionnaire to be filled in every week for as long as they were at sea as well as the wearing of actigraphs (Figure 1). The weekly questionnaire contained questions on sleep (Karolinska Sleep Diary, KSD, environmental conditions disturbing sleep, etc.), on health and fatigue (Karolinska Sleepiness Scale, KSS, Multidimensional Fatigue Inventory, MFI-20, depressive symptoms, etc.) as well as on work (work difficulty, workload, social support at work, etc.).

3. Results

Data from the background questionnaires reveal what is typical sleep/wake- as well as work behaviour among seafarers. Average working-time is 69 ± 11 hours per week and 83% of seafarers do overtime work at least once a week. 50% of seafarers report having split sleep (i.e., 2 sleep episodes of >1.5 hours per 24h). Self reported daily sleep need is 8,2 ± 1,1 hours, self reported daily sleep duration only 7,7 ± 1,5 hours. 70% of seafarers

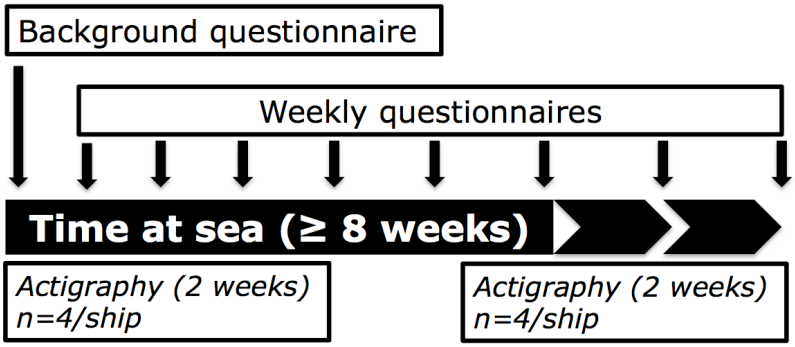

Figure 1. Design of the field study.

nap once a week or more. Twice as many report being morning type as compared to evening type. 43% report higher fatigue levels at the end of a journey at sea compared to the start. Coffee consumption is considerably higher during working days (2,8 ± 1,9 cups) than during days off (1,0 ± 1,2 cups).
The weekly questionnaires reveal no accumulation over time of sleep related problems including sleepiness and fatigue. Substantial individual differences, however, do exist and environmental factors like port calls, time zone shifts, weather and temperature have a substantial influence on sleep and recuperation at sea.

4. Conclusions

Working conditions among seafarers are very demanding: working times are very long and do usually not permit sufficient time for rest and recuperation. Although fatigue does not increase with time at sea, randomly occurring environmental factors may at times increase the risk for fatigue and stress, which eventually may jeopardize safety at sea (Jepsen et al., 2015).

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Implementation of RAMP method at Scania

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Introduction

This is a presentation of an ongoing project at Scania: How to implement the new ergonomic method "RAMP" globally within Scania, truck producer. This is a practitioners report of the implementation.

The risk management tool is called RAMP, “Risk assessment management tool for manual handling proactively”. The tool has been developed by Carl Lind and Linda Rose at KTH, “The Royal Institute of Technology in Stockholm”. The tool consists of a checklist (RAMP I) and an assessment tool (RAMP II) which can be used to assess physical risk factors associated with manual handling. The tool provides guidance for action plans and evaluations to promote improvements.

Aim

Expected benefits were to reduce risks for musculoskeletal disorders among employees who are working with manual handling.

Background

There was a need within logistics and machining to find one comprehensive method to use globally for assessing manual handling. The method should involve different aspects of load ergonomics. It resulted in a mandate from the top management in production and logistics.

Globally Scania has plants in different parts of the world but this project was initially implemented in Sweden, France, Netherlands, and finally in Brazil.

How the project has been run

Ergonomists from the health department within Scania have cooperated with a lot of departments in the Scania organization.

Step 1: Ergonomists globally have practiced and evaluated the practical usability of the RAMP method.

Step 2: Ergonomists have cooperated with technicians from logistics and machining. They have made pilots and evaluated, the way of working and the usability. The way of working is different between the plants in France and Brazil compared to Netherlands and Sweden.

Step 3: Training concept was developed.

Step 4: Training for technicians started.

Step 5: The different departments within logistics and machining are responsible for continuous improvements regarding assessments, activities and follow up. The ergonomist is a support for the department and for the technicians.

Through the whole process there has been close cooperation with management teams at different levels.

Results and feedback

So far we have achieved step 4. Some departments have developed a more specific strategy for step 5 and started the implementation.

Generally there has been a positive response from the participants in the project. Throughout the project there has naturally been the challenges and problems that had to be solved.

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Information on the RAMP method at KTH homepage: https://www.kth.se/en/sth/forskning/halso-och-systemvetenskap/ergonomi/forskning/ramp-utveckling-implementering-och-spridning-av-belastningsergonomiskt-bedomningsverktyg-och-atga-1.60371

Work fatigue and occupational health of seafarers – case studies in European and Chinese shipping industry

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Fatigue has negative impacts on the general working population as well as on seafarers. In order to study seafarers' fatigue, a questionnaire-base survey was conducted to gain information about potential risk factors for fatigue and construct indexes indicating fatigue. The study applies T-test to compare strata of seafarers to analyse work and sleep patterns in global seafaring. Qualitative analysis are also employed to explore the impacts of fatigue on seafarer's occupational health and safety.

Keywords: Fatigue, Seafarers, Work and sleep patterns, T-test

1. Introduction

Among the general working population, fatigue has been associated with accidents and injuries (Allen et al., 2008; Bonnet and Arand, 1995) and also linked to ill health (Andrea et al., 2003; Barger et al., 2005; Van Amelsvoort et al., 2002) as well as to poorer work performance (Beurskens et al., 2000; Charlton and Baas, 2001), sick leave and disability (Janssen et al., 2003). In shipping the extent of research on fatigue is more limited. The Cardiff Seafarers' Fatigue Research Programme (Smith et al., 2001, 2003 and 2006) set out to remedy this and concluded that many of the risk factors for fatigue found in other industries were present in combination in maritime work (Allen et al., 2005 and 2006). They confirmed the importance of fatigue as a factor in accident causation (Wellens et al., 2005) and ill health (Wadsworth et al., 2008). In order to optimize the legal framework internationally and nationally, and to promote safe and healthy sleep patterns in merchant shipping, it is important to explore the current provisions for sleep at sea in an international perspective and whether they are adequate and also understand the symptoms and impacts of fatigue on seafarers.

2. Method

454 and 483 seafarers in two European and two Chinese shipping companies, respectively, answered a questionnaire and 51 in-depth interviews were carried out in order to further elaborate into the issue. All interviews were tape recorded. The survey and interviews participants' anonymity and data confidentiality are kept intact.

Questionnaire was a revised version based on the questionnaire designed and employed in the

Cardiff Seafarers' Fatigue Research Programme. The questions were selected from the original questionnaire with an aim of exploring long-term fatigue and related factors in order to explore the question: how organisational practices and individual factors influence fatigue, what methods should be applied for preventing and managing seafarers' fatigue and what are the effect of applying different strategies. In addition to DEMOGRAPHICS, the questionnaire consists of 6 sections, focusing on seafarers JOB/VESSEL, HOURS OF WORK AND REST, FATIGUE AT SEA, ABOUT THE WORK, SLEEP PATTERNS & HEALTH-RELATED BEHAVIOURS, TRAVEL TO AND FROM THE VESSEL. 937 questionnaires were collected altogether, among which, 454 questionnaires were collected from European, accounting for 48.5% of the total number and 483 from China with a proportion of 51.5%. 506 questionnaires are filled out by officers representing 54.0% of the sum and 390 by ratings constituting 41.6%. Questionnaires from Deck department take up 52.1% with a number of 488 and others from Engine department make up 379 of the total number. 99.1% respondents are male (n=929) whose average age is 36.07(media=33, range=19 to 69). Indexes indicating tiredness at work, sleep quality and distress at work were constructed by using scale reliability (Cronbach'α>0.8) and weighted mean. Strata were compared by application of a T-test. Additionally, 51 in-depth interviews were carried out in order to further elaborate into the issue. The issues around seafarers' fatigue were explored deeply by drawing on both quantitative and qualitative data to analyse the symptoms and impacts of fatigue.

3. Result

As Table 1 shows, compared to contract work time, European and Chinese seafarers had higher actual weekly work hours, respectively(European: $p<0.001$, mean difference = -4.14, 95%CI = (-5.31, -2.96), Cohen's d = -0.29, 95%CI = (-0.44, -0.14); Chinese: $p<0.001$, mean difference = -3.73, 95%CI = (-4.80, -2.66), Cohen's d = -0.41, 95%CI = (-0.58, -0.24)). It can be seen from the table, there was no significant difference between European seafarers' actual sleep and their ideal amount of sleep ($p=0.005$, mean difference = -0.28, 95%CI = (-0.80, -0.56), Cohen's d = 0.16, 95%CI = (0.03, 0.29)). However, Chinese seafarers' actual sleep was less than ideal amount of sleep ($p<0.001$, mean difference = -0.68, 95%CI = (0.09, 0.48), Cohen's d = -0.51, 95%CI = (-0.64, -0.37)). A similar situation emerged between Ratings and Officers, that Ratings' actual sleep and ideal sleep length were not significantly different while Officers' actual sleep length was less than their expectation. In addition, Chinese seafarers' ideal sleep length was longer than that of European seafarers ($p<0.001$, mean difference = -0.92, 95%CI = (-1.10, -0.74), Cohen's d = -0.67, 95%CI = (-0.80, -0.53)). Compared to European seafarers, Chinese seafarers experienced lower quality of sleep and suffered more distress and tiredness at work(Sleep quality: $p<0.001$, mean difference = -0.38, 95%CI = (-0.45, -0.31), Cohen's d = -0.71, 95%CI = (-0.84, -0.58); Distress: $p<0.001$, mean difference = -0.67, 95%CI = (-0.76, -0.57), Cohen's d = -0.94, 95%CI = (-1.10, -0.79); Tiredness: $p<0.001$, mean difference = -0.46, 95%CI = (-0.58, -0.35), Cohen's d = -0.54, 95%CI = (-0.68, -0.41)). A similar situation can be detected between Ratings and Officers that Officers had poorer sleep quality and suffered more distress and tiredness than Ratings did at work. Concerning seafarers fatigue in general, the analysis shows that fatigue influences seafarers health and safety at sea in a negative way. Seafarers suffered from a number of accurate and chronic health problems.

Table 1. Descriptive Statistics

	Chinese seafarers(Mean)	European seafarers(Mean)	Officers(Mean)	Ratings(Mean)
Age	34.18 (n=461,SD=9.16, S.E=0.43)	38.06 (n=443,SD=10.49,S .E=0.49)	36.66 (n=486,SD=9.81, S.E=0.45)	35.57 (n=379,SD=10.07, S.E=0.52)
Sailing Age	8.36 (n=469,SD=7.78, S.E=0.36)	13.58 (n=405,SD=9.30, S.E=0.46)	11.59 (n=480,SD=9.16, S.E=0.42)	9.81 (n=364,SD=8.42, S.E=0.44)
Contract work hours(weekly)	56.93 (n=294,SD=9.42, S.E=0.55)	58.57 (n=341,SD=14.05, S.E=0.76)	59.20 (n=325,SD=12.26, S.E=0.68)	56.34 (n=284,SD=11.90, S.E=0.71)
Actual work hours(weekly)	60.40 (n=283,SD=10.58, S.E=0.63)	63.58 (n=382,SD=14.11, S.E=0.72)	64.52 (n=346,SD=12.62, S.E=0.68)	59.73 (n=291,SD=12.72, S.E=0.75)
Amount of time at sea	7.91 (n=367,SD=1.23, S.E=0.07)	5.32 (n=367,SD=1.82, S.E=0.10)	6.13 (n=408,SD=2.26, S.E=0.11)	7.29 (n=298,SD=1.51, S.E=0.87)
Actual sleep	8.06 (n=444,SD=1.61, S.E=0.07)	8.06 (n=441,SD=1.94, S.E=0.09)	7.82 (n=484,SD=1.76, S.E=0.08)	8.38 (n=365,SD=1.78, S.E=0.09)
Ideal sleep	8.68 (n=457,SD=1.22, S.E=0.06)	7.76 (n=442,SD=1.52, S.E=0.07)	8.13 (n=490,SD=1.42, S.E=0.06)	8.36 (n=373,SD=1.50, S.E=0.08)
Sleep quality	1.24 (n=472,SD=0.59, S.E=0.03)	0.86 (n=452,SD=0.47, S.E=0.02)	1.16 (n=501,SD=0.56, S.E=0.03)	0.93 (n=386,SD=0.55, S.E=0.03)
Distress at work	1.39 (n=420,SD=0.81,S. E=0.04)	0.73 (n=424,SD=0.61, S.E=0.03)	1.21 (n=475,SD=0.79, S.E=0.04)	0.87 (n=342,SD=0.74, S.E=0.04)
Tiredness at work	2.17 (n=449,SD=0.91, S.E=0.04)	1.71 (n=431,SD=0.82, S.E=0.04)	2.09 (n=472,SD=0.87, S.E=0.04)	1.78 (n=374,SD=0.89, S.E=0.05)

4. Conclusion

According to the analysis, conclusions can be drawn: significant difference can be found between contract work hours and actual work hours as well as between actual sleep and ideal sleep, which indicate suboptimal work and sleep patterns in global seafaring; there are significant differences in between strata of seafarers (rank, nationality) and it suggests that work hours and sleep are the factors which relate to seafarers' fatigue; current management of fatigue risks is inadequate and seafarers' health and safety are negatively influenced by fatigue; the shipping industry can do more for its seafarers to have a healthier and safer working environment.

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Accuracy of a posture measurement system for practitioners

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This paper presents an evaluation of a feasible inclinometer system, for measurement of static and dynamic body postures, which can be used by practitioners. The system, an inclinometer based on a triaxial USB-accelerometer and an analysis program (Excel Macro), was compared with measurements obtained with a gold standard, i.e. an optical 3D motion capture system. The angles obtained with the inclinometer, had a high correlation with the corresponding angles of the optical motion capture system, for static upper arm postures above 0.997 for both abduction and flexion. At fast arm movements, the absolute difference in angles between the two systems was low, 4.1°, 5.4° and 3.6° at the 10th, 50th and 90th percentile respectively. This study indicates that this feasible and inexpensive ($140) inclinometer system (USB-accelerometer and Excel Macro), can be used to obtain upper arm inclination data of quality comparable to that of many research studies where direct measurements have been used.

Keywords: Movements, direct measurements, inclinometer, accelerometer, observation, arm elevation

1. Introduction

Awkward body postures are considered a major risk factor for work-related musculoskeletal disorders and pain (Bernard, 1997). Frequent flexion, rotation and lateral bending of the trunk have been associated with an increased risk of low back disorders (Bernard, 1997; Punnett et al., 1991) and prolonged upper arm elevation have been associated with both shoulder and neck disorders (Mayer et al., 2012; Svendsen et al., 2004). For example, Svendsen et al. (2004) found that the risk of neck disorders significantly increased for each additional percent of work time with upper arm elevation >90°. However, such small differences can be difficult to detect using self-reports or observations, due to their generally lower degree of accuracy and precision (Juul-Kristensen et al., 2001; Lowe, 2004; Burdorf, 2010). Therefore, the use of more valid (direct) measurements, like inclinometers, could be an attractive alternative or complement.

Due to technical development, direct measurement devices have now become feasible to use also for non-researchers. Such a device, the X16-2 accelerometer (GCDC, Mississippi, US), is a triaxial USB-accelerometer that saves data into text files, and can be used for measuring postures in a cost- and time-efficient way. The USB-accelerometer can be used as an inclinometer, together with a new software (Excel Macro) that we have developed. When analyzing a measurment, the user simply plugs the USB-accelerometer into a computer and starts the macro, and thereafter selects the just recorded file. Thereafter, the measurments are presented in a few seconds in a graph, as percentiles (10, 50, 90, and 99), and as percentage of the time above 45°, 60°, and 90°. If these types of system are precise and accurate, they have the

potential to be a viable complement when performing an exposure- or risk-assessment, also for non-research purpose.

Therefore, the aim of this study was to assess the accuracy of this new inclinometer system (i.e. the USB-accelerometer combined with the Excel Macro), for measurements of upper arm inclination, during static and dynamic conditions, by comparing it to measurements obtained with an optical motion capture system.

2. Methods

In order to test the accuracy of the inclinometer two static (Experiment 1) and one dynamic (Experiment 2) evaluations were carried out, on one male volunteer (age 34 years). The inclination angles from the new system were compared with those simultaneously obtained from a gold standard, i.e. an optical motion capture system (Elite 2002, BTS, Milano, Italy).

Triaxial accelerometers can measure the inclination with respect to the line of gravity (vertical axis) and can be used to measure the inclination of e.g. the upper arm or the trunk (Hansson et al., 2006). The accelerometer used in this study, a digital triaxial accelerometer (X16-2, cost $140, http://www.gcdataconcepts.com/x16-2.html, retrieved 2015-09-04), has a maximal recording rate of 400 Hz (at 15bit). However, in this study, a sampling rate of 12 Hz was used and the data was filtered at 6 Hz using a program developed by one of the authors (Mikael Forsman). The accelerometer (figure 1) was mounted on the participant´s left upper arm at the insertion of the m. deltoideus (Bernmark & Wiktorin, 2002).

As reference (gold standard), an optical motion capture system (Elite 2002, version 2.8.4380, BTS, Milano, Italy), located at Karolinska Insitutet, was used. The eight-camera-system has a sampling rate of 100 Hz and can measure human movement with an accuracy of about ± 1 mm, by tracking small reflective markers mounted to different body segments (Grooten et al., 2013). Two reflective markers were mounted on the participant's left upper arm. The first marker was mounted about 3 cm below the acromion and the second one at the lateral epicondyle of the humerus (Bernmark and Wiktorin, 2002).

In order to evaluate the accuracy of the inclinometer system for static postures, the participant performed two flexion (Experiment 1a) and two abduction trials (Experiment 1b), with the arms held static for five seconds, at elevation angles of about 30°, 60°, 120°, 150° and 180°. The mean angle from each interval was calculated, based on three seconds after the first peak value, at each elevation angles. In the evaluation of dynamic movements (Experiment 2), the participant performed three 30-second-trials of arm-swings in the sagital plane (flexion-extension), from about 0° to about 150° and back (0°) at 0.4 Hz, paced by a metronome. Each trial was followed by a rest period of at least 30 seconds. From these three trials, the distribution of upper-arm elevation angles was calculated from a total of 30 arm-swings. Several test-runs were conducted a priori the evaluations, to enable the participant to familiarize with the procedures.

To define the vertical line in these experiments, a normalization procedure was performed by which the participant sat on a chair leaning to the left (lateral flexion) for ten seconds while holding a two-kg dumbbell in the left arm (Bernmark and Wiktorin, 2002; Jackson et al., 2015).

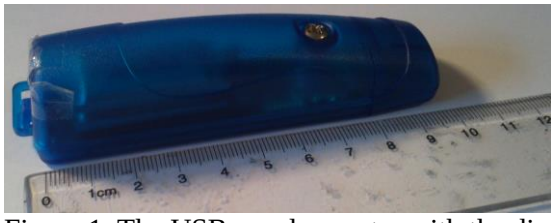

Figure 1. The USB-accelerometer with the dimensions, in cm, 10 x 2.5 x 2.4.

3. Results

The results from Experiment 1 and 2 are presented below.

3.1. Experiment 1 – Static upper arm flexion and abduction

The results from Experiment 1 (figure 2A and 2B) show a high correlation between the inclinometer (USB-accelerometer) and the motion capture system. There was an almost perfect correlation for both upper arm flexion (figure 2A) and abduction (figure 2B), with a correlation coefficient of 1.0 (0.9975) and 1.0 (0.9988), respectively. However, for upper arm abduction of about 90° or more (see figure 2B), slightly lower elevation angles were obtained by the inclinometer compared to the angles obtained by the motion capture system.

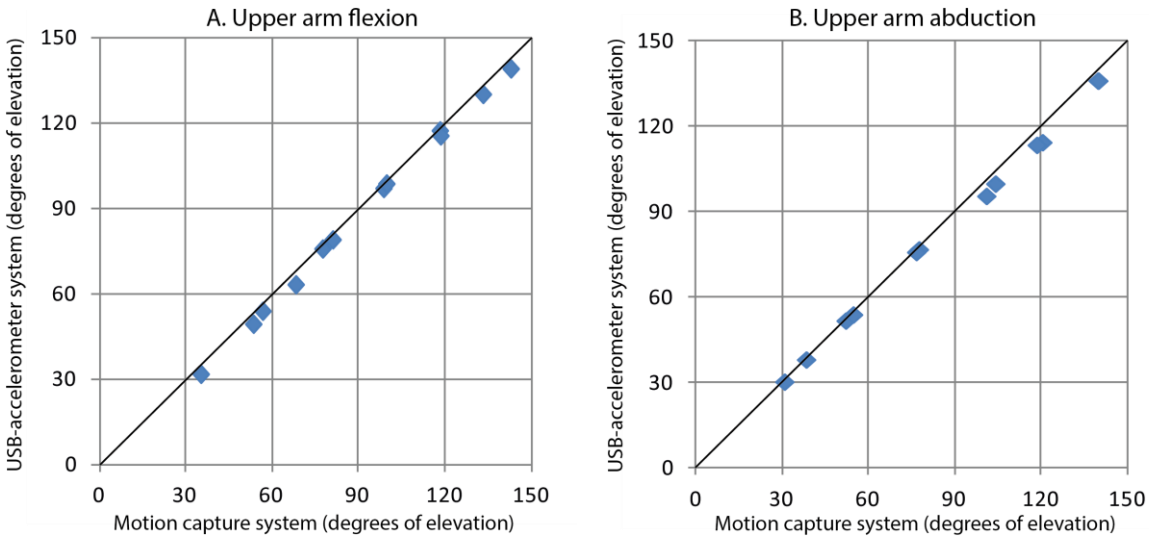

Figure 2. Upper arm flexion (A) and abduction (B) measured by the two systems in Experiment 1. The data in the figures are based on the mean value of first three seconds from the first peak value at each elevation angle. The black line shows the line of perfect fit between the two systems.

3.2. Experiment 2 – Arm-swings (sagittal plane)

At the fast arm movements (0.4 Hz), the absolute differences in angles between the two systems were 4.1°, 5.4° and 3.6° at the 10th, 50th and 90th percentile (Table 1). The absolute differences between the measurements (at the percentiles presented below) are all below six degrees. This divergence between the two systems, can be seen in figure 3, in which three randomly chosen arm-swings are displayed.

Table 1. Distribution of the measurements (arm-swings) at 0.4 Hz, obtained by the two systems in Experiment 2, and their absolute differences.

Upper arm elevation			
Percentile	USB-accelerometer system (°)	Motion capture system (°)	Absolute difference (°)
99th	135.0	129.2	5.8
95th	129.6	125.2	4.4
90th	126.0	122.4	3.6
75th	107.6	110.1	-2.5
50th	67.7	73.1	-5.4
25th	32.3	32.4	-0.1
10th	21.5	17.4	4.1
5th	19.7	15.9	3.8
1th	17.8	14.1	3.7

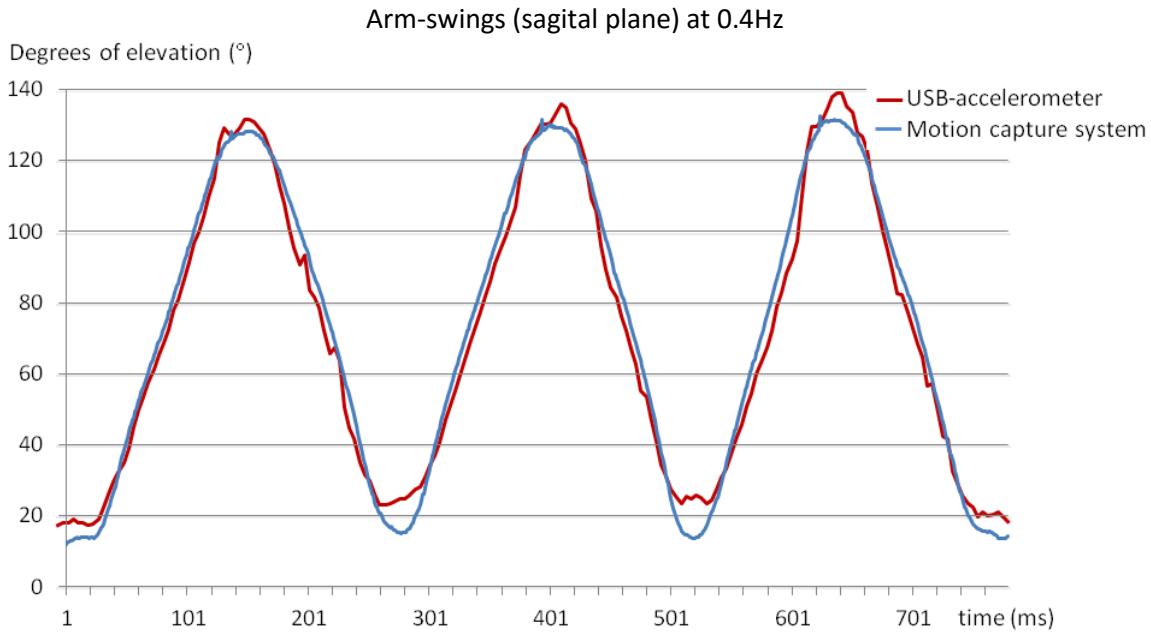

Figure 3. The figure shows an example of the measured upper arm elevation angles, obtained simultaneously by the two systems (the USB-accelerometer and the motion capture system) in Experiment 2, during arm-swings.

4. Discussion and conclusion

The measurements obtained with the inclinometer system, used in this study, showed high agreement with a gold standard, especially at static postures. At low velocity (static posture) the errors were very small, while at fast movements, the absolute differences between the two systems ranged from 0.1° to 5.8°. The results from this study were based on one participant and should therefore be interpreted with some caution. However, it seems unlikely that the very strong correlations, found in this study, are due to chance. Hence, strong correlations between the two systems are likely to remain if the number of subjects were to be increased.

This study, in which the present inclinometer was mounted on the arm so that its accelerometer (which is in a corner of the device) were located as close as possible to the shoulder joint, indicated an overall difference up to about 5° at fast upper arm movements. These larger deviations in the dynamic test were expected and are in agreement with previous investigations (e.g. Bernmark and Wiktorin, 2002). Since accelerometers measure forces due to acceleration and gravity, during rapid movements, there is always an inherent error in using accelerometry in measurements of arm elevation. This is described by Bernmark and Wiktorin (2002). Furthermore, Bernmark and Wiktorin (2002) showed that the error between the inclinometer and an optical motion system in their study was more pronounced at high frequencies of arm-swings than at lower frequencies. Therefore, it is very likely that the difference between the two systems in this study at high velocities would decrease when measuring moderate and slow movements. Considering that no real job includes movements of this high velocity over any substantial amount of time, and that the between-days and between-subjects variability during strictly standardized work tasks have been quantified to 3.4° and 4.0°, respectively (Hansson et al., 2006) these levels of deviation are in most cases acceptable. Hence, this study indicates that the accuracy of this system in occupational settings is comparable with those reported previously in the scientific literature (e.g. Palmerud et al. 2012; Arvidsson et al., 2012).

In conclusion, this study indicates that this feasible and inexpensive inclinometer system (USB-accelerometer and Excel Macro) can be used to obtain upper arm inclination data

of quality comparable to that of many research studies where direct measurements using inclinometers have been used.

5. Acknowledgements

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A comparison of two methods for assessment of assembly complexity – what are they good for?

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This study aimed at comparing two methods for assessing manual assembly complexity, the CXB considering basic assembly complexity from product design perspective and the CXI, which assesses complexity as perceived by operators in production. The objective was to see if and how the two methods overlap. The results showed that they had some assessment criteria in common but that other criteria differed and covered different areas of interest. Both method approaches are important for a manufacturer to manage in order to create sustainable assembly conditions, good working conditions and reduce errors in manual assembly.

Keywords: Basic assembly complexity, Complexity index, Assembly, Operator, Errors.

1. Introduction

Increasing global competition for customers has forced many companies to enhance and diversify their product range, which requires a strong customer adaptation and a high level of cost efficiency at the same time. This has resulted in increased product and manufacturing complexity due to increasing number of product variants and numerous build options in mass production. (ElMaragy, 2012; Schleich et al, 2007; Orfi et al., 2011; Rekiek et al., 2000).

This situation puts very high demands on production and the operators who are supposed to assemble many different product variants with different special solutions in paced assembly lines. The more assembly options that are available to the operators, the more assembly-related errors occur according to Zhu et al. (2008) who concluded that in order to prevent this from happening system solutions, assembly solutions, material, methods and tools must enable as flawless assembly as possible. Bishu and Drury (1988) similarly found that the more information gain there was due to many assembly options the more likely would failures occur.

Mattsson et al. (2012; 2014) studied how operators perceive assembly complexity at station level in the production plant. The objective was to see what conditions that influenced assembly complexity as perceived by operators and how it could be measured and managed. For that purpose a complexity index (CXI) was developed. Falck and Rosenqvist (2014); Che'ramy and Ittner (2013) on the other hand, studied the impact of basic assembly complexity criteria (CXB)[1] on assembly and product quality by measuring manual assembly errors and associated action costs in the automobile industry. They found that the higher the assembly complexity, the higher were the costs for correction of assembly-related errors in manual assembly. CXI and CXB have the same overall objective, i.e. reduction of assembly errors and associated action costs in manual assembly. Hereby, the purpose is to increase efficiency, manufactured quality

[1] Basic assembly complexity: The basic design of products, components and system solutions decided in early product development phases. Basic complexity criteria include both physical and cognitive factors.

and productivity and decrease assembly-related costs. However, CXB focusses on basic installation conditions, i.e. basic assembly concepts and solutions, while CXI focusses on and evaluates the conditions in the production process that the operators must manage. Since both methods assess assembly complexity but are using different approaches, the objective of this study was to compare the two methods to see how and to what extent they complete each other and where they differ.

2. Method

To enable comparison between the two assessment methods these were applied on the same assembly tasks in a European truck assembly plant. The company is one of the largest truck companies in the world with focus on heavy trucks over 16 tons and has production facilities in nine countries and about 35 000 employees.

About 60 trucks/day were completed at the time for the study and about 600 different variants are regularly built. A line section that comprised four assembly stations including ten assembly tasks were chosen for comparative analysis. The assembly time for each station was 7.4 minutes and each assembly task took between 60 – 507 seconds to complete. The average assembly time per task was 170.4 seconds. Examples of studied tasks are front bumper, head lamps, corner lights and washer fluid can. The number of male operators were nine plus one additional resource. The median age and general operator experience was 43 and 12 years respectively.

2.1. The questionnaire and CXI assessment.

The questionnaire included 26 different questions divided into six subsections: product variants, work content, layout, tools and support tools, work instructions and others. The operators were asked to fill in one questionnaire for each of three or four different work tasks. Newly employed operators on the current line section only filled in questionnaires for work tasks they knew well. Each question had six different answer options: *1: don´t agree -> 5: fully agree* and *6: don´t know/not relevant.* By using a special formula, the average of all respondents' median CXI of their answers for each of the six subsections was calculated. High values of the subsections that showed individual differences among the respondents´ answers were also considered. A CXI value was then calculated for each of the ten assembly tasks. The template for classification of CXI is shown in Table 1.

Table 1. Score boundaries for CXI.

CXI value	CXI level	Colour	Action
<2	Low	g (*green*)	No investigation needed
≥ 2 and <3	Middle	y (*yellow*)	Need investigation
≥3	High	r (*red*)	Need urgent investigation

2.2. Assessment of basic assembly complexity (CXB).

CXB assessments of the ten assembly tasks were made by the company ergonomist and research engineer in cooperation with the researcher who developed the CXB method (see Falck et al. 2014). Accordingly, sixteen criteria for assessment of complexity level were used (Table 2). For each criterion the answer was either "yes" (the criterion was met) or "no" (the criterion was not met). The number of fulfilled criteria was then summed up for each of the ten assembly tasks. The more criteria that are met the higher is the complexity level. The template for classification of CXB level is shown in Table 3.

Table 2. Brief description of the 16 CXB criteria. A more detailed description as outlined in the paper by Falck et al. (2014) was used in the assessment.

1. Many different ways of doing the task
2. Many individual details and part operations
3. Time demanding operations
4. No clear mounting position of parts and components
5. Poor accessibility
6. Hidden operations
7. Poor ergonomics conditions implying risk of harmful impact on operators
8. Operator dependent operations requiring experience/knowledge to be properly done
9. Operations must be done in a certain order
10. Visual inspection of fitting and tolerances, i.e. subjective assessment of the quality results
11. Accuracy/precision demanding tasks
12. Need of adjustment
13. Geometric environment has a lot of variation (tolerances), i.e. level of fitting and adjustment vary between the products
14. Need of clear work instructions
15. Soft and flexible material
16. Lack of (immediate) feedback of properly done work, e.g. a click sound and/or compliance with reference points

Table 3. Template for assessment of CXB level based on the number of met criteria (n = 0 -16).

CXB level	Degree of complexity	Fulfillment of criteria	
1	Low	0-3	(0-19%)
2	Rather low	4-7	(44-25%)
3	Moderate	8-11	(50-69%)
4	Rather high	12-14	(75-88%)
5	High	15-16	(94-100%)

2.3. Comparison of complexity level between the CXB and the CXI methods.
The average CXB level for each assembly task was compared with corresponding average CXI level based on the results of the questionnaires. The CXI and CXB results were then analyzed further by analyzing both similar and different findings.

3. Results

In total, 31 correctly filled in CXI questionnaires were collected concerning the ten assembly tasks. The average number of answers per question in the questionnaires was 3.1.

The comparison between the CXB and CXI levels and values per assembly task showed that the average CXB level was rather low with an average value of 6.7 while the corresponding average CXI level was high with an average CXI value of 3.82 (Table 4).

A comparison between the 16 CXB criteria and the contents in the CXI questionnaire showed that nine questions did not correspond to any of the sixteen CXB criteria. Seven CXI questions were however related to a greater or lesser extent to some CXB criteria. These were criteria number 2, 4, 5, 6, 7, 8, and 14. After removal of the questions that did not agree at all with any of the CXB criteria the CXB and CXI values were re-calculated for the ten assembly tasks. Fig. 1 and 2 displays all tasks before and after removal of non-corresponding questions. After removal Fig. 2. shows a better agreement between CXB and CXI values than Figure 1.

Assembly task 1-6 in Fig. 2. had a correlation coefficient of 0.93 while the assembly tasks 7-10 showed a correlation coefficient of -0.63.

Table 4. Levels and values per assembly task for CXB and CXI respectively.

No.	Assembly task	CXB level	CXB value	CXI level	CXI value
1	Multiconsole	Rather low	7	High	3.79
2	Headlight, outside	Low	3	High	3.65
3	Headlight, inside	Moderate	10	High	3.88
4	Cornerlight, inside	Moderate	10	High	5
5	Headlight frame	Low	1	High	3.29
6	Bumper, plastic	Moderate	8	High	3.92
7	Bumper, coated sheet metal	Moderate	11	Moderate	2.58
8	Footstep, FM	Rather Low	4	High	4.25
9	Footstep, FH	Moderate	4	High	4
10	Washer fluid can	Moderate	9	High	3.83
Average:		**Rather low**	**6.7**	**High**	**3.82**

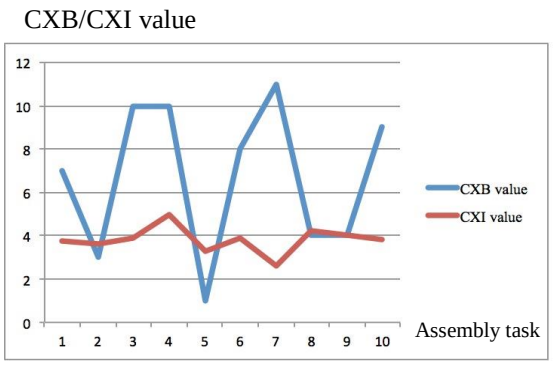

Fig. 1. CXB-CXI comparison, all questions.

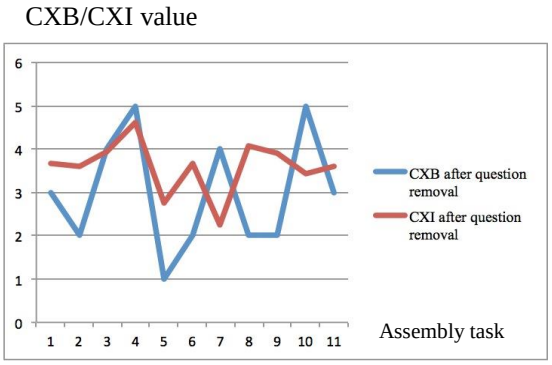

Fig. 2. Comparison after removal of non-agreeing questions.

4. Discussion

To compare two different ways of measuring complexity is difficult. Besides, this pilot study only made it possible to study a limited number of operations and workers. Therefore, firm conclusions cannot be made but the results should be seen as indications. Yet, the objective was to see if and how the methods overlap and differ. Both the CXB and CXI approaches are important for a manufacturer to manage. The most optimal way is of course to prevent complex assembly concepts and solutions already in early product and production development. This requires adequate monitoring systems enabling basic complexity analyses and that errors reported can be traced back to the causing operation. Yet, very few companies log the required information and follow-up data as long as necessary (Falck et al., 2014; Beevis and Slade, 2003). Another option is therefore to use the CXI method to improve assembly conditions for the operators on site and reduce assembly-related errors and reactive action costs as far as possible. However, CXI cannot change basic assembly complexity very much since only seven of sixteen CXB criteria agreed with CXI questions to some extent. These were CXB criteria # 2 *Many individual details/part operations to keep track of;* # 4 *No clear mounting position,* # 5 *Poor accessibility;* # 6 *Hidden operations;* # 7 *Ergonomics;* # 8 *Operator dependent operations;* # 14 *Need of detailed work instructions.*

The operators assessed the CXI level much higher than the experienced company ergonomist and research engineer assessed the CXB level. The average CXB level was rather low while the

CXI level was on average unexpectedly high. It could not be excluded that other factors have influenced the answers in general, e.g. psychosocial factors, experienced stress and work satisfaction that CXB does not consider. In fact some of the operators were relocated to the current line section due to work-related and other problems of different kind that might have influenced their anonymously filled in answers. The CXI is based on 26 questions aimed to comprehensively cover current assembly conditions on the work site including e.g. work contents, work organization, information flow and human performance and influencing cognitive and environmental factors. CXB cannot take these aspects into account in the same way. CXB more exclusively evaluates assembly complexity from a product design perspective including basic assembly conditions before products are put into production. However, CXB still considers some operator conditions from both cognitive and physical (ergonomics) aspects. A more extensive study ought to be made in order to explore the reason for the differences and possibly closing the gap between the methods.

5. Conclusions

The CXI and CXB methods have some parts in common and could complete each other in other respects. However, in this study the results of the two assessment methods disagree. Both methods aim at increasing quality through reduction of assembly-related errors but in different ways. CXB should preferably be used in early product development phases while CXI focusses on production-related conditions from the operator´s perspective. Both CXB and CXI approaches are important for a manufacturer to manage in order to create sustainable assembly conditions, good working conditions and reduce errors in manual assembly.

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Development and validation of a novel iOS application for measuring arm inclination

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Work in demanding postures is a known risk factor for musculoskeletal disorders, specifically work with elevated arms may cause neck/shoulder disorders. An iOS application was developed to measure arm elevation angle, using built-in accelerometers and gyroscopes of iPhone/iPod Touch. The application was validated in motion lab for four subjects, with a correlation coefficient above 0.99 and absolute errors below 4.8° in arm flexion and abduction positions. The application showed similar accuracy with other tested field research methods. It should be useful for ergonomists for risk assessments or educational use, with low cost and high convenience.

Keywords: Accelerometer, Gyroscope, Physical work exposure, Smartphone

1. Introduction

Shoulder musculoskeletal disorders (MSDs) and complaints are common among the working population (van Rijn et al. 2010). Research studies have shown that working with elevated arm is a risk factor for shoulder disorders (NIOSH 1997; Svendsen et al. 2004; Miranda et al. 2005).

Accelerometers as inclinometers to assess arm elevation have been widely used for research purposes over the last decade (Jackson et al., 2015). Inclinometer validations against optical system (Bernmark & Wiktorin, 2002) and electromagnetic system (Korshoj et al., 2014) have shown that inclinometer systems have satisfactory precision for static postures and slow-to-medium paced movement. While for fast movement, the acceleration from the device motion will add signals upon the gravity, introducing systematic errors to the measurement (Bernmark & Wiktorin, 2002; Korshoj et al., 2014).

Most smartphones have embedded tri-axial accelerometers and gyroscopes. This offers the possibility of developing smartphone application as an arm inclinometer. Practitioner researchers are mostly smartphone users, so the convenience and low cost of using an app as a measuring device is attractive (Milani et al., 2014). Moreover, combining the built-in gyroscope and accelerometer enables access to gravity data separated from acceleration, which should facilitate precise measurement even during fast movement. IPhone/iPod Touch (Apple Inc.) usually has a standard design within generations, and it is more common than other smartphones (Milani et al., 2014; Franko 2011). The aim of this study was to develop and validate an iOS application for measuring arm inclination under static and dynamic conditions.

2. Methods

2.1 Development of the iOS application

This application was developed by using a development tool – Xcode 6.2, and compiled programming language – Swift (Apple Inc.). In Xcode, the device acceleration and gravity signal can be obtained directly by using the Core Motion frame, based on a sensor fusion algorithm used by Apple Inc. using built-in accelerometers and gyroscopes (Apple Inc. 2011).

Data sampling and processing. The sampling frequency of the embedded accelerometers and gyroscopes is set at 20 Hz (as in Hansson et al. 2006; Bernmark & Wiktorin 2002). A 6th order Butterworth low-pass filter, with a cut-off frequency of 5 Hz, was applied to the acceleration and gravity signal (as in Korshoj et al. 2014).

Inclination calculation. The inclination angle from the phone (θ_{pho}) was calculated from gravity data (a_G) and total acceleration data (a_{total}) respectively. The average data of calibration procedure was taken as reference vector (a_{x0}, a_{y0} and a_{z0}), presenting 0° elevation. Inclination was then calculated using the acceleration/gravity signal (a_x, a_y and a_z), relative to the reference vector. Angular velocity was calculated using the first-order central differences of the inclination angle.

2.2 Validation experiment

A validation experiment was conducted using a 3D optical motion capture system Elite 2002 (BTS Bioengineering, Italy). The iOS application was installed in an iPhone (Apple Inc., 6th generation, iOS 8.3). Four right-handed subjects participated in the test (two women and two men). Two reflective markers were used: one was placed on the lateral epicondyle, and one on the caput humeri, 3 cm caudal to the border of acromion (Bernmark & Wiktorin, 2002). The iPhone was positioned with the upper edge on the insertion of deltoid and the long axis along with humerus, fixed using a sport armband (Belkin, USA), see Figure 1-A. Prior to the experiment, calibration was conducted by letting the subject sit and lean slightly to the side, holding a 2 kg dumbbell for 2 s (Bernmark & Wiktorin, 2002).

The validation procedure included: (1) arm flexion and abduction (45°, 90°, 135° and 180°), each angle posture for 5 seconds, (2) three types of arm swing in the sagittal plane through whole motion range, with the help of a metronome at 0.1 Hz, 0.4 Hz and 0.8 Hz, each for 30 seconds, and (3) simulated painting on a board (height around 1.8 m) for 3 minutes, as shown in Figure 1-B & C.

Inclination angle from the optical system (θ_{opt}) was then calculated using the 3D coordinates of two markers in Matlab.

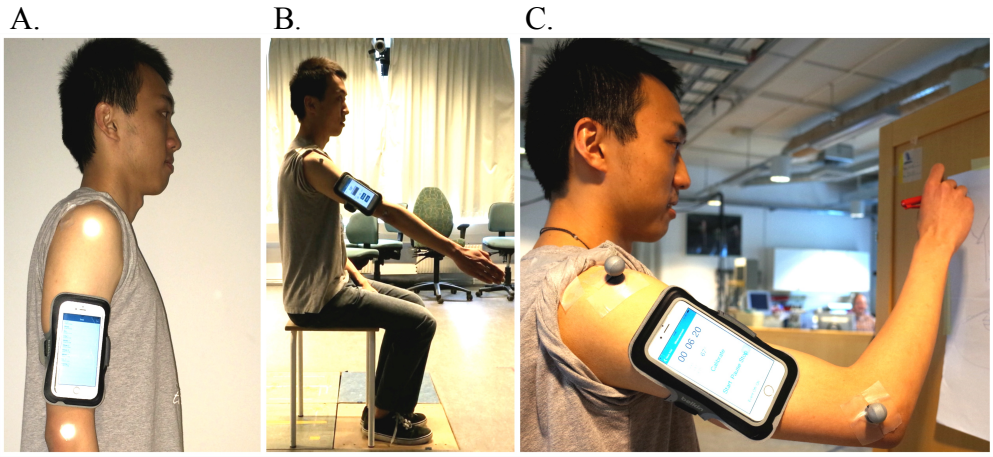

Figure 1: Validation experiment in the optical motion lab. A: Placement of two reflective markers and the iPhone with armband. B: Arm flexion posture. C: Painting on a straight board.

3. Results

3.1 The functioning of the iOS application

The user interface was designed to be self-explanatory, with support by two ergonomists. The start view is the list of all the recorded trials, see Figure 2-A. By clicking button "+", users can create a trial and give the trial name and number. Then comes the measurement view, where users can easily 'Create', 'Calibrate', 'Start', 'Pause' and 'End' a measurement, see Figure 2-B.

The buttons are inactivated when not supposed to be pressed, which reduces the possibility of human error, see Figure 2-C.

Result parameters are calculated and presented directly after the measurement, including the 50th and 90th percentiles of angular distribution, time percentage of arm inclination over 30°, 60° and 90°, and the median (50th percentile) of angular velocity distribution, as shown in Figure 2-D. Complete data set and result parameters can be transmitted directly via email.

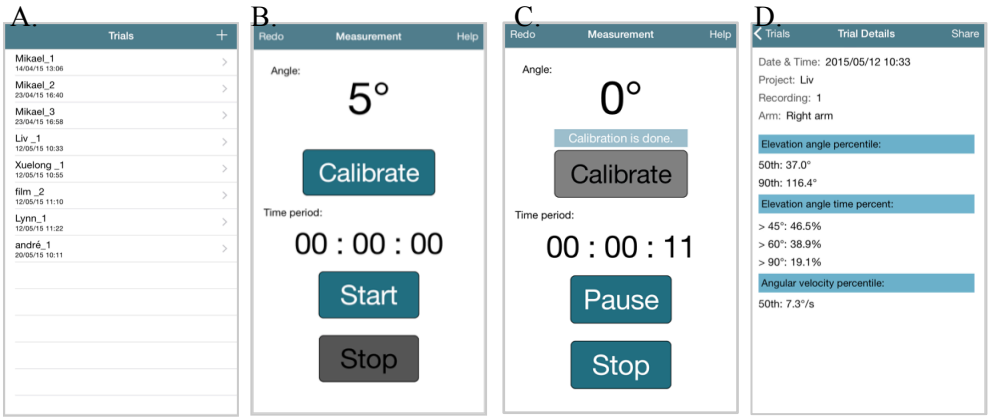

Figure 2: Part of the user interface of the iOS application, including A: Trial list view; B&C: Measurement view; D: Measurement result view.

3.2 Validation results

Synchronisation was done in order to compare the iPhone system with the optical system. The signal from the phone (20 Hz) was resampled to match the signal from optical system (100 Hz). The alignment of two signals was done using Matlab. A few data points were missing because of lost-track markers, and these were interpolated from tracked nearby points.

Static postures. The correlation coefficient between the optical system (OPT) and the iPhone system (PHO) for arm flexion postures was 0.9992, see Figure 3-A. The mean difference value (PHO - OPT) was 1.4°, and the limits of agreement (mean ± 1.96 SD) was -1.5° to 4.4°, see Figure 3-B (Bland-Altman plot). For arm abduction, the correlation coefficient for arm abduction postures was 0.9965. The mean difference value (PHO - OPT) was 1.5°, and the limits of agreement was -4.0° ± 7.0°.

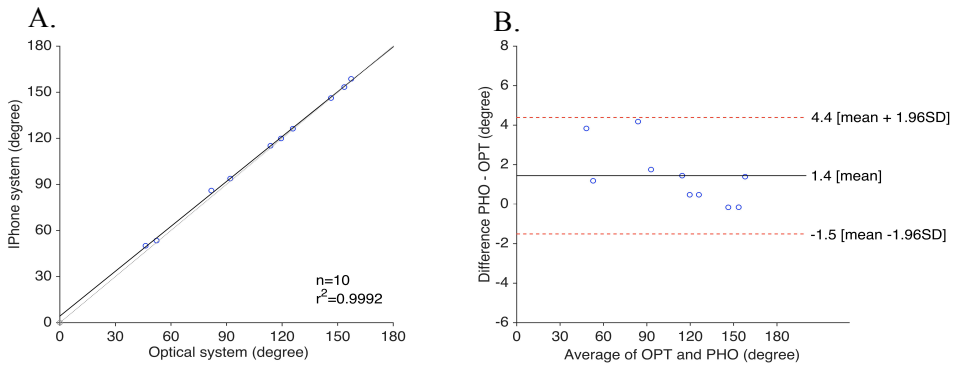

Figure 3: Upper arm inclination measurement during arm flexion. A: Linear correlation plot; B: Bland-Altman plot.

Dynamic movements. The mean RMSDs between the optical system and iPhone system for three different arm swings and simulated painting are shown in Table 1, including the mean RMSDs at the 10th, 50th and 90th percentiles of the angular distributions and time percentage of

upper arm inclination above 30°, 60° and 90°. The highest mean RMSDs, were seen for simulated painting, 5.4° at 10th percentile and 8.7 %time at inclination above 90°.

Angular velocity. The mean RMSDs of the median angular velocity between the optical and iPhone system were 2.7°/s, 7.6°/s and 7.5°/s at slow, medium and fast arm swing, and the values from the optical system were 40.0°/s, 123.8°/s and 245.0°/s respectively.

Gravity and acceleration signals. The data from gravity and total acceleration signal were compared with the optical system for three arm swings. They showed similar accuracy in slow swing, while the accuracy of total acceleration signal turned worse when the speed turned higher. One sample for fast pace swing was plotted for illustration, including data from optical system, gravity signal and acceleration signal from the phone (Figure 4).

Table 1: Mean RMS differences (RMSDs; °) for three subjects between the optical system and iPhone system, at slow (0.1 Hz), medium (0.4 Hz) and fast (0.8 Hz) arm swing and simulated painting. The values from the optical system are given within brackets.

	Arm Swing			**Painting**
Percentile (°)	Slow	Medium	Fast	
10th	0.8 (10.8)	1 (13.3)	1.4 (13.7)	5.4 (22.1)
50th	1.2 (53.9)	0.5 (51.4)	3.1 (57.1)	5.0 (72.1)
90th	2.1 (140.6)	2.2 (127.9)	3.8 (116.5)	5.3 (94.7)
Time percentage				
>30°	1.1% (69.6%)	1.5% (74.8%)	1.9% (75.6%)	1.0% (85.2%)
>60°	0.7% (43.7%)	0.9% (41.0%)	2.2% (47.2%)	4.0% (71.2%)
>90°	1.4% (34.1%)	1.4% (33.1%)	4.0% (28.9%)	8.7% (17.5%)

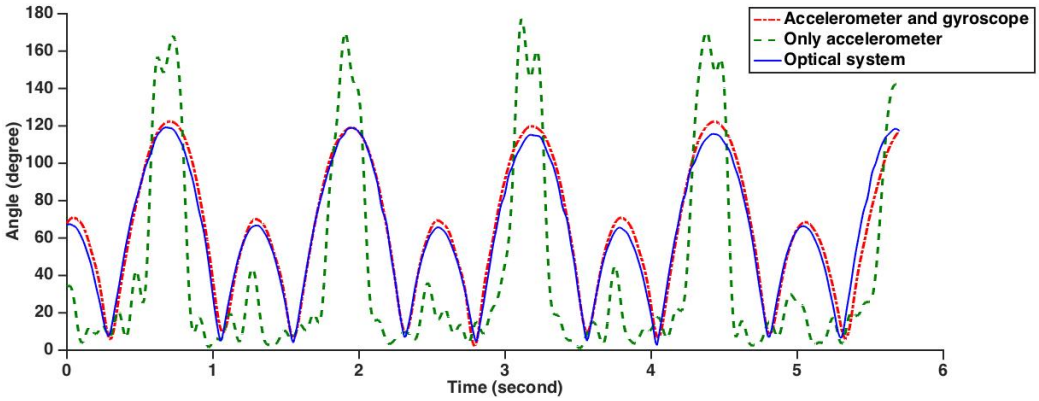

Figure 4: One sample of upper arm inclination during fast swing (0.8 Hz, i.e. 48 swing/min), comparing the optical system with gravity and total acceleration from the phone system.

4. Discussion

This iOS application showed equivalent accuracy compared to other validated inclinometers for upper arm elevation measurement. For rapid movement, this application showed distinct improvement by combining signals from accelerometers and gyroscopes, compared to accelerometer alone.

It has been put forward that different mounting places of the inclinometer on the upper arm, e.g. mounting atop the deltoid muscle or with the upper edge at the insertion of deltoid muscle, could result in a systematic error (Jackson et al. 2015). Also, soft tissue artifact can introduce error not only in the iPhone system but also the optical system. Compared to previous validated accelerometers, the difference was similar: the mean RMSE of upper arm inclination was roughly 5° for most arm movements (Korshoj et al. 2014).

For the simulated painting, it had largest RMSDs comparing angle percentiles and time percentage above 90° between the optical and iPhone system. These differences are much possibly due to that the arm was always in a rotating movement, where soft tissue artifact affected a lot on the precision of both optical and iPhone systems; besides, the arm was mainly elevated up and down between 60° to 90°, which was just around the cut off value 60° and 90°.

The validation experiment was just conducted with one iPhone device, and there might be inter-device differences, which need to be further tested. Moreover, it would be interesting to see the performance of the iOS application in a field trial with a higher number of test subjects.

In ergonomics practice, this application would serve as a good alternative to other validated (accelerometer-based) inclinometers. It has the advantage of cheap cost, easiness for use and directly obtained results. While the comparably larger size of an iPhone/iPod Touch may limit the applicability to long duration measurement. When used as a measurement tool to evaluate the differences in arm inclinations between, e.g., two workstations, or in an instructional lecture, the application would be sufficiently informative and reliable.

The plan is that the application will be free to download from the App Store (Apple Inc.).

Acknowledgement

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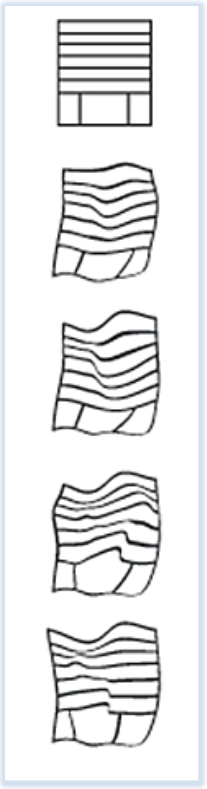

Creating Sustainable Work-environments

Nordic Ergonomics Society 47th Annual Conference

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Poster Session

Evaluation of workplace health among dental care employees in a Swedish county council - a salutogenic perspective

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Abstract

1 Introduction

The dental team in Sweden, includes dentists, dental hygienists and dental nurses. Also, clinic coordinators, who administrate and coordinate daily works, and managers, who are responsible for the staff and economy includes in the team. Changes of the proportion of different occupations in the dental care organization, as seen in Sweden, may influence the work and responsibilities, such as integration, cooperation and delegation of different work tasks within the dental team, which, in turn, may influence the staff's health and work environment [SoS, 2009]. In this context, evaluating employees' health and work environment is important for health promotion at workplace. Workplace health promotion refers to strategies to maintain and improve the health and wellbeing of the employees [ENWHP, 2007], which is line with the salutogenic theory [Antonovsky, 1987]. Studies using a salutogenic approach would provide a valuable complementary perspective on the health and work environment of dental staff rather than just focus on risks i.e. pathogenic perspective. The aim was to explore self-reported psychosocial health and work environment among different dental occupations and workplaces from a salutogenic perspective.

2 Methods

Employees in the Public Dental Service in a Swedish county council (n =486) were invited to answer a survey including demographics, health and work-related factors. Based on the salutogenic theory, three validated measurements were used; the Sense of Coherence scale [Antonovsky, 1987;1993], the Salutogenic Health Indicator Scale (SHIS) [Bringsen, Andersson. et al., 2009] and, the Work Experience Measurement Scale (WEMS) [Nilsson, Andersson et al, 2013]. The SOC scale, comprises 13 items and consists of three dimensions: comprehensibility, manageability and meaningfulness. The SHIS includes twelve items considered to represent complexity and breadth and cover a cognitive, a physical and a psychosomatic dimension of health. The WEMS includes 32 statements divided into six dimensions: supportive work conditions, internal work experience, autonomy, time experience, management and reorganization. The data were analysed statistically using IBM SPSS Statistics, version 21. The project has been approved by the Regional Ethical Review Board in Linköping (ref. no: 2012/186-31).

3 Results

Of the total sample, 301 participated (272 women) and were 21-68 years old. Clinical coordinators, who administrate and coordinate daily works, reported better overall health (SOC=75.1 points and SHIS=58.1 points) compared to the other professions (SOC; 68.4-72.1 points and SHIS; 49.4-49.8 points; p=0.01), and so did dentists (SOC=71.2 points) and dental hygienists (SOC=72.1 and SHIS= 53.0 points) compared to dental nurses (SOC = 68.4 points; SHIS=49.8 points; ($p<0.05$). For work experiences (WEMS), men experienced greater autonomy compared to women (17.7 and 13.8 points respectively; $p<0.000$). Those younger than 40 years reported higher total work experience, expressed by higher meaningfulness, happiness, job satisfaction, and greater autonomy and were more positive to reorganisation compared to 40-59 year-olds (149.3 and 141.6 respectively; p=0.028). Clinical coordinators reported the highest degree of total work experience (156.1 points; $p<0.05$) expressed by, autonomy, management and reorganisation. Dental hygienists and nurses experienced less time pressure than dentists (12.4, 12.5 and 10.8 points respectively; p=0.07). Autonomy was reported to a lesser degree by dentists and dental hygienists than dental nurses (17.0, 16.2 and 12.1 respectively; $p<0.000$). Better health and positive total work experience were shown in smaller clinics ($\leq$10 employees) compared to larger clinics (SOC =73.8 points compared to 68.7 points; p= 0.18 and WEMS= 149.1 compared to 140.2 points; p=0.29).

4 Discussion

The dental employees can in this study be considered as a healthy profession but with some variation between different employee characteristics. Depending on the profession (nurses, physicians and medical technicians) and the workplace (hospital and office), this has also been seen to vary in earlier studies [Bringsen, Andersson et al., 2009; Bergstrom, Miller et al, 2015; Hoge, Bussing, 2004; Orly, Rivka et al., 2012; Takeuchi and Yamazaki, 2010]. A feeling of participation and motivation and having control and access to resources may both be associated with the profession and the work position (managing position or not). Also, working conditions, such as the content and perceived meaning of the work, may be influencing factors. WEMS is a tool that identifies strengths and resources in the health promotion work at a workplace [Nilsson, Andersson et al., 2013]. In the current study, several healthy resources at the dental workplace were identified: higher internal work experiences and autonomy, positive time experience, positive to management and reorganisation. These results, with a salutogenic approach, implies that several health resources and processes within a workplace influence the dental employee's health and workplace experience and must be considered planning for work place health promotion. Applying a salutogenic approach to a workplace within the health service, where restructuring and demands for increased productivity occur (as in the dental service in Sweden) has been shown to be a way to maintain and/or improve employee health (specifically mental health) [Kuoppala, Lamminpaa et al., 2008; Nilsson, Andersson et al., 2012; Nilsson, Andersson et al., 2013; Graeser, 2011]. From a dental care perspective, our reflection on this is that dental personnel who work in a salutogenic workplace may be a better resource for their patients.

4.1 Conclusion

This study showed associations between employee characteristics and self-reported overall psychosocial health as well as experienced work environment. It is important to identify resources and processes in the health promotion work at a workplace. In future evaluations of dental workplace health and environment aiming to understand health and risks in the dental workplace, we recommend that the salutogenic perspective is added to the risk assessment.

Key words: Dental staff, Health promotion, Psychosocial health, Workplace.

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WORKPLACE DESCRIPTION – A USEFUL TOOL IN REDUCING SICKNESS ABSENCE.

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A workplace description is a tool used in the following up program for absence from work due to work-related musculoskeletal disorders. It describes the work tasks and gives an assessment of the working conditions which are characteristic for the work-place. The central aim of using this tool is to secure a better and more purposeful communication between the employee on sick leave, his general practitioner, the employer and the Occupational Health Services in order to reduce sickness absence.

Keywords: occupational health services, musculoskeletal disorders, sickness absence

1. Introduction

Occupational Health Services (OHS) in Norway are organized in small units, normally with doctor, nurse, occupational hygienist and a physiotherapist or ergotherapist employed. Each OHS serves either several small enterprises or one bigger enterprise. "Inclusive Working Life" is a national intervention program in Norway. The objective is to reduce sickness absence, prevent early retirement and to promote employment of employees with impaired capacity.

Companies may become an "Inclusive Working Life" enterprise by signing an agreement with the National Insurance Service. The OHS is supposed to play an active role in supporting the enterprises in their effort to reach the aims of the intervention program.

2. Background

The employee on sick leave, his general practitioner, his employer and the representative of the OHS are often the four most central actors in all activity following up absence due to work-related musculoskeletal disorders. The doctors will in their assessments put emphasize on the employee`s functional ability in relation to the demands of the workplace situation. This assessments require sufficient knowledge about the patient`s work environment, which is not always present. The assessment is normally only based on informal information given by the employee himself and thus may be limited or biased (Gudding IH, 2002).

Most working situations are complex and the relationship between work environment and health may be even more complex. A "workplace description" presented by OHS might be crucial as basis for this assessments and contribute to a more purposeful communication between all the actors involved and especially between the doctor and his patient and between the doctor and the employer.

3. Methods

A suitable "workplace description" is brief, never more than two pages and with the information divided in two parts. The first part describes the working tasks performed. The employer should be responsible for this part of the description. The head of the department is always the best one to describe every single task related to the actual work situation and the responsibilities of his department.

The last part of a “workplace description” presents an assessment of the working conditions which are characteristic for the workplace. It requires professional competence on work-related risk factors for developing musculoskeletal disorders and should be based on collaboration between the employer and the OHS (Gudding IH, 2010, Gudding IH, 2015)

The physiotherapist or the ergotherapist in the OHS who are well-educated in ergonomics and know the risk factors for work-related musculoskeletal disorders, are often involved in formulating this part of the “workplace description”.

3. Purpose

The “workplace description” gives all actors involved a common fundamental knowledge about the working environment, and a more solid foundation for the decision on which tasks the employee may do or not, related to his health problem. It is always up to the employee to provide complementary information or personal experiences, if he believes that essential elements in the description of his workplace are excluded.

A “workplace description” may be useful in all contexts where it is necessary to describe the types of tasks the employees on sick leave may perform or not. A ”workplace description” based on the employers initiative and his responsibility for a good personnel policy, provides several advantages. It can be made for special needs or prepared as a procedure, which makes it easily available when needs arise. If it is appropriate to transfer an employee to another workplace in the company, multiple alternatives of “workplace descriptions” may be used as basis for the actual assessments.

4. Results

Several OHS have through the years adapted the idea of formulating a “workplace description”. Already in 2005, a survey sent to 100 OHS showed that 78% of the physiotherapists representing these OHS, used “workplace descriptions” in their professional support to the enterprises (Gudding and Lie, 2005). Since then several OHS have presented practical examples where they use “workplace descriptions” systematically as a tool in their communication with the “Inclusive Working Life” enterprises. The aim of this communication is to play an active role in supporting the enterprises in their effort to reduce sickness absence as one of the aims of the “Inclusive Working Life” intervention program.

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Towards optimal task distribution between the nursing staff and the support services by a resilient, reliable and easily accessible comprehensive support service system

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This study aimed at optimizing the allocation of tasks between the nursing staff and the support services. Using participatory design and focus groups based workshops involving both the nursing staff and the staff of the support service, a variety of practical ideas to improve the material supply services as well as the material logistics to match the needs of the nursing staff were constructed and taken into practice. As a theoretical result, main characteristics of an optimal support service system were obtained and thus we suggest a comprehensive support service system that is resilient, reliable and easily accessible.

Keywords: healthcare, material supply, nursing staff, logistics, organizational development, participatory design, resilience, support service, task distribution, work system

1. Introduction

At the moment, the healthcare system is going through a change due to ageing population and thin resources as well as on the other hand, due to technological advances and development. New methods and techniques for medical treatment and an increasingly diverse range of medical supplies offer novel solutions to a wide variety of medical conditions.

This study is carried out as a part of the multidisciplinary project "Effective, user-centred and scalable support service models in long distance health care systems". The focus of this study is the task allocation between the nursing staff and the support services. Principles of participatory design and development (Spinuzzi 2005) are used to find new solutions and courses of action, while taking simultaneously into account productivity and the well-being of the employees' at work.

The concept of work system has been used in the inspection of the healthcare system comprising of the core process (nursing) and the support service. The relationship between these two parties forms the subject of examination in this study. The work system, which was originally presented in ISO Standard 6385 and studied by Smith and Sainfort (ISO Standard 1981; Smith and Sainfort 1989; Carayon et al., 2000, 2014; Hignett et al., 2013; Holden et al., 2013), spans the employee (person), her/his task, available technology and tools, and the work environment as well as the organization in which the work takes place. The work consists of processes that result in either desirable or non-desirable outcomes. The processes involve each of the sections in the work system and the output depends on both the input and interrelation of these sections.

Earlier research on the subject has been carried out in the same target organization of Lapland Hospital District by Paananen et al. (2011). This study focused on the empowerment of employees and the personnel participation in development projects carried out in many areas. The current study can be seen as a sort of continuity for the work of Paananen et al. with a focus on the task division and the support services, which was one of the development areas of the earlier study. Intra-organizational communication plays a major role in organizational development and even more so when participatory human-centred approach in design and development is used. Väyrynen et al. (2014 a), for instance, have studied the improvement of

intra-organizational communication in six Finnish industrial companies and among others this research gave utilizable examples of how to emphasize and improve human-centred communication skills while carrying out development projects.

2. Objectives

The aim of this study was to find solutions for task allocation between the nursing staff and the support services that increase the amount of the desirable output, such as well-being and productivity while minimizing the non-desirable outputs, such as errors and excess strain. The investigation was carried out on two levels: on the practical level by creating and implementing real-life development ideas in the target organization and on a more theoretical level by contemplating the roles of the support service and the nursing staff with the help of the work system concept.

3. Methods

The study was conducted using participatory design and development (Spinuzzi 2005) involving both nursing staff as well as the staff of logistics and material supply services of the target organization. The methods used were based on action research (Masters 1995), and involved observation, focus group based workshops, a survey and semi-structured interviews.

3.1. Theoretical background

Action research both studies and changes predominant practices. It can be defined to be a collective self-reflective inquiry carried out by participants in a social situation or an organization in order to improve the rationality of their own social or educational practices (Masters 1995). Independent of the emphasis of the used definition, action research features acquisition of knowledge, empowerment of participants, collaboration through participation, and social change.

The acquisition of knowledge can be carried out in many ways, one of which is observation. By observing the behaviour and actions of the subject of study, it is possible to gain direct and in some cases more objective information than for example through interviews. Ethnography is a wide research strategy, which concentrates on participating in and observing the relevant processes of the studied system. (Flick 2007) Ethnography-based observation techniques can be used in action research.

Participatory design and development is a natural companion to action research (Spinuzzi 2005). Already early on it has been shown that even-handed involvement of the employees in the development of work processes is connected with work satisfaction, work ethic and productivity (Coch and French 1948). One of the methods often used in participatory design is focus group, where the participants can engage in conversation in a group setting on a subject or theme introduced by the researcher (Langford and McDonagh 2003).

Action research can also be viewed as a spiral process that consists of four elements: planning, acting, observing and reflecting (Masters 1995). This bears close resemblance to plan-do-check-act (PDCA) -cycle that is widely used in business for continuous improving of processes and products.

3.2. Fieldwork

The fieldwork of this study was carried out in a central hospital environment in Lapland Hospital District in Finland in cooperation with the nursing staff of the target department as well as with the logistical and material supply services of the hospital.

First, the work of the nursing staff and the logistical and material supply services was observed in order to find coinciding nodes in their work. Tasks of each party within the work system were observed for 2.5 working days. The data from the observations was used both as a background information and in preparation of the workshops.

After the observation, three participatory design workshops involving both parties of employees were organized. The workshops were carried out as focus groups where the employees worked together to create ideas to improve the material supply services and logistics to match the nursing staff's needs. The participants of each workshop were comprised of two nursing staff members (nurses, practical nurses), two material supply service staff members and the researcher. Also the superior of logistical and material supply services took part in one of the workshops. The role of the researcher was to raise questions and enable the creation of ideas in an approving environment. A survey and semi-structured interviews were used after the workshops to gain more information on certain aspects of ideas originating from the workshops and their implementation.

4. Results

The results of this study are two-fold: The workshops resulted in 12 practical ideas that concern the material supply services in stock refill, internal courier services as well as the communication and interaction between the nursing staff and the support services. Besides these ideas, the employees participating in the workshops conveyed views and experiences upon which it was possible to contemplate the characteristics of an optimal support service system resulting in both well-being of the employees and productivity.

4.1. Practical development ideas

As mentioned, the first part of the results of this study is formed by the 12 ideas originating from the workshops. These can be divided into three categories: 1) broadening the material supply services in stock refill, 2) creating an internal courier service to transfer logistical tasks from the nursing staff to the support services and 3) enhancing the information flow, communication and interaction between the nursing staff and the support services. Several of these ideas either are or will be implemented in the target organization to test their functionality. The ideas are presented in Figure 2 accompanied by colour coding indicating the status of the execution of each idea at the end of the field work period.

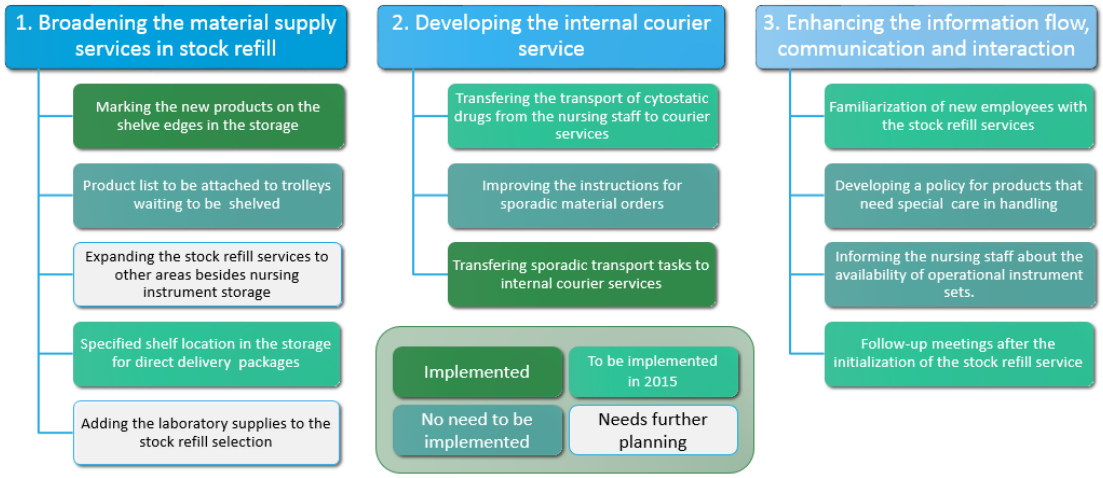

Figure 1. The 12 practical development ideas that were created in the focus group based workshops can be divided into three separate categories. The color coding indicates the status of execution of each idea at the end of the field work period.

4.2. Characteristics of an optimal support service work system

The theoretical results of the study comprise the main characteristics that can be defined to be present in an optimal support service work system according to the views and experiences conveyed by the employees of the target organization. These are resilience, reliability, ease of access and comprehensiveness. The well-being of the nursing staff at their work can be

promoted through acts leading to experienced reliability and security that enable them to concentrate on the actual nursing work.

5. Discussion

As mentioned in the introduction, the concept of the work system was used as a framework to examine the work processes and the interface between nursing work and the support services. Considering the aforementioned comprehensive support service system, a work system that includes both the core process (nursing) and the support services can be constituted (Figure 4). The relationship between these two components is defined by the task of the support services, which is to enable the core process. Besides this task, the core process and the support services share the physical environment as well as the organization to a level that depends on the details of the system in question. To ensure optimal performance, all the parts of this two-fold scheme as well as their interplay must work seamlessly.

The support services in the field of healthcare bear a resemblance to the suppliers in an industrial network (Väyrynen et al. 2014 b). The concept of inter-organizational shared workplace common in industry might be applied to healthcare, where several support services are needed in order to enable the treatment and care of patients by the nursing staff. Social sustainability, as well as high, consistent level service quality, can be promoted through specialised tools such as HSEQ Assessment Procedure presented by Väyrynen et al. as well as through participatory design and development and the empowerment of employees in organizational development projects in a wider perspective.

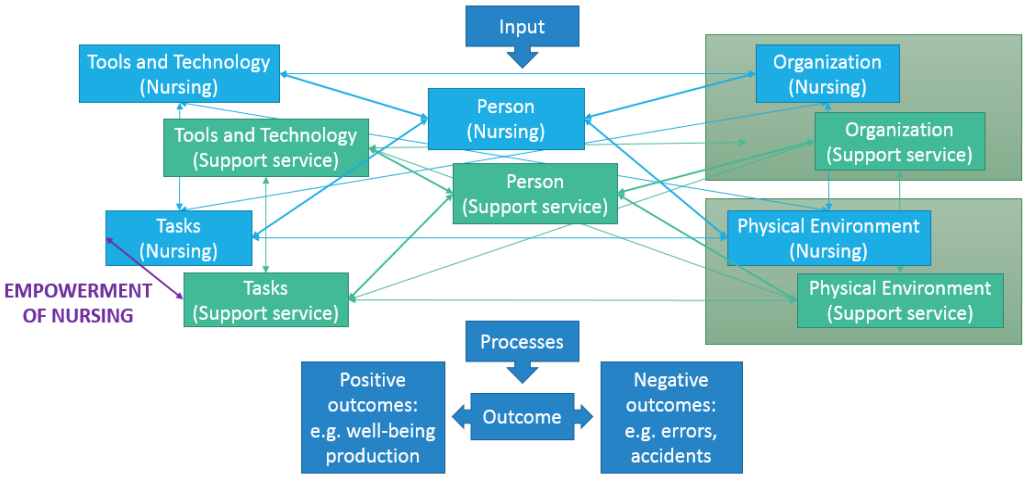

Figure 4. The work system applied to the combination of core process (nursing) and support service.

6. Conclusions

In this study new solutions and courses of action in task allocation of support services and nursing staff in healthcare environment were sought to increase both well-being at work and productivity. A set of 12 development ideas considering the task distribution of the nursing staff and support services was created using participatory design. Based on these ideas and the views of the employees of both parties, we suggest a comprehensive support service work system that is characterized by three properties: resilience, reliability and ease of access.

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Patient´s perception of quality of care in Swedish dentistry.

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Changes in a dental organization may affect both work environment for professionals and patients' perception of quality of care. The aim of the study was to explore patients' perception of quality of dental care, measured as patient satisfaction. The design was a cross-sectional study and participating patients were asked to answer a self-reported questionnaire consisted of 31 questions directed to dentistry and the abbreviated version of the Humanism scale. The majority of the participants experienced a high degree of satisfaction with the quality of received dental care and care-givers humanistic behavior but statistically significant differences were found within sex, age groups and different native language.

Keywords: patient satisfaction, dental care, patient perception

1. Introduction

Within dentistry in Sweden, there are shifts in the labor market i.e. less number of dentist, and simultaneously there are changes in the populations' need of oral care and dental treatments (National board of Health and Welfare [NBoHW] 2014). These new demands in dentistry are met in different ways such as restructuring of work tasks and adjustment of number of staff members in different professional categories, e.g. equal or more dental hygienists than dentists. The National Board of health and welfare has established criteria's for good dental care, including knowledge-based and patient-focused care, and identified a need for improved knowledge management and evaluation in order to maintain high quality in dental care (NBoHW 2010). The purpose of restructuring the organizations is to establish efficient dental care and by that achieve the national goals of dentistry. However, these changes in an organization may affect the work environment and dental care quality, both from a professional point of view and from patients' perception of received good quality dental care. Before making major changes in health care organizations there is a need of evaluation at multiple levels, such as organization/resources, processes and outcome. Patient satisfaction is an important part of the patients' perspective of quality of care and a part of evaluation at outcome level. The patients' perspective should be considered when evaluating work environment in dentistry because it can be considered as an evaluation of the combined function of organization/resources and processes levels (Donabedian 1966).

2. Objectives

The aim of the study was to explore patients' perception of quality of dental care, measured as patient satisfaction. Furthermore the study aimed to explore if there were any differences in

perceived patient satisfaction within different subgroups.

3. Methods

The design was a cross-sectional study performed in a Swedish County Council. The study population was based on a sample carried out by a two-step cluster sampling and the selection was conducted consecutively at each clinic. All Public Dental Service Clinics in one Swedish County Council were divided into two categories depending on the ratio between the number of dentists and dental hygienists who worked at each clinic in October 2012. Altogether ten clinics were randomly selected, five clinics from each category. Patients were asked to answer a self-reported questionnaire which consisted of 31 questions directed to dentistry and the abbreviated version of the Humanism scale, measuring patient's perception of the caregiver's humanistic behavior. Focus was directed towards information, treatment and overall impression. Patients were divided into subgroups related to clinic category (1<1/1>1), gender (male/female), age, native language (Swedish/non-Swedish), and level of education (Elementary school/High school/College or University). Data were analyzed with Pearson's Chi²-test, Mann- Whitney U Test and Kruskal-Wallis Test using SPSS version 22 (IBM Corp, Armonk, New York, USA). This research was approved by the Regional Ethical Review Board in Linköping (ref. no: 2012/186-31).

4. Results

Results are based on 204 patients and show in general a high level of patient satisfaction, with both received dental care and caregiver's humanistic behavior, among the majority of the participants. Of all participants 93 (45.6%) answered *"Excellent"* when asked: "How would you overall rate the dental treatment you received?" and 92 (45.1%) answered *"Very good"*. However, dividing and analyzing subgroups, statistically significant differences were found within groups. Men (n= 104) experienced less satisfaction with information of self-care than women (n=100). Of the male participants 76 (73.1%) and of the female participants 80 (80.0%) answered that they were satisfied with the information about self-care that they received (p=0.021). Among the youngest (20-39 years) more participants experienced less possibility to talk to their caregiver about worries or anxiety than participants in the oldest age group (60- years). In the youngest age group (n=54) 17 (31.5%) felt they could talk to their care-giver about worries or anxiety compared to the oldest age group (n=62), where 23 (37.1%) felt able to talk to their caregiver (p=0.020). Statistically significant differences were also found within groups based on native language. Participants with another native language than Swedish had less confidence in their caregiver and lower satisfaction with the information they received about treatment options. When asked if they had confidence in their caregiver 14 (82.4%) answered *"Yes"* compared to participants with Swedish as native language of which 180 (96.3%) reported same answer (p=0.040). Of the participants with another native language than Swedish 4 (23.5%) reported lower satisfaction with the information they received about treatment options compared to participants with Swedish as native language of which 12 (6.5%) answered *"No"* (p=0.010).

5. Discussion

As also shown in this study, good or very good assessments have previously been reported within the research area focusing on patient satisfaction (Ståhlnacke et al. 2007, Bedi et al. 2005, Skaret et al. 2005). However, in the current study some groups were less satisfied, which reflects on the importance to evaluate the patient perspectives working with quality improvements in dentistry (NBoHW 2010). Some consideration should be taken on the number of participants in some subgroups although the study sample reflects both the demographic composition in the County Council and the visiting frequencies in these subgroups. Self-reported questionnaires has been seen to be a good tool for measuring patient satisfaction and it

is often the only opportunity a patient has to express their experiences and/or perceptions, which should not be underestimated (Williams 1998). If high visiting frequencies continues as well as high ratings in degree of satisfaction, this may be an indication of how patients considers an organization change, for example an increasing transition to more dental hygienists than dentists. Research shows that there are differences in patients' attitudes to different dental profession categories (Öhrn et al. 2008, Sun 2010). According to these studies, patients' have a more positive attitude towards dental hygienist than dentists. A shift in staff composition structure by equal or more numbers of dental hygienists than dentists may therefore be seen as a quality improvement from a patient satisfaction perspective. Thus, in reorganization it is important to have a holistic and humanistic perspective in the evaluation of dentistry, both from a patient's as well as the professional's point of view.
Conclusion: The majority of the participants experienced a high degree of satisfaction with the quality of received dental care and caregivers' humanistic behavior. However, statistical significant differences were found within subgroups in some areas. In reorganization, it is important to evaluate how the impact of work environment in dentistry affects patient satisfaction.

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Better working environment with recurrent ergonomics rounds.

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1. Introduction.

Never before has the history been more illuminating on the human potential and its value, including Human Resource Management. Also we even work more to produce the most efficient working methods that will lead to profit. The fierce competition has only reinforced machine bureaucracy since structures are becoming clearer within organisations.

2. Aim and methods.

The purpose of the continuous ergonomic rounds has been, and is, above all, to prevent ill-health in the working environment at Clas Ohlson and catching up early signals of the employees directly to each department.

The method has been to work with staff on site to find solutions to such as heavy lifting, how to work the best way, with best body support; including online help, for example, with good exercises to prevent greater problems.

Each visit is followed up with a dossier of management; for example, suggestions for good ergonomic interventions-then the continuous assessment of what has been done; When? Where? How?

3. Results.

By increasing the ergonomics knowledge of the individual, promote contact between layers of staff, managers and management commitment and the working environment is improved, which in the long run probably also improve the company's finances.

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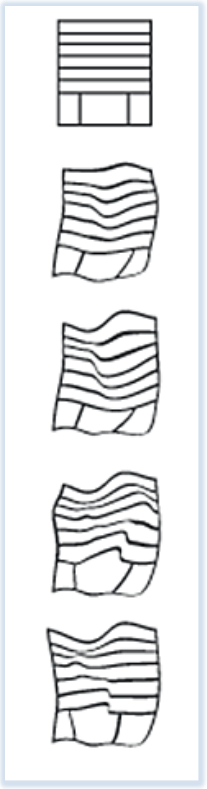

About Lillehammer

Lillehammer is a small city by the inland lake Mjøsa, which is Norway's largest lake. Nature based activities and sports are important in the region, winter sports in particular, there is a ski jumping hill as well for those interested. Many of the Olympic venues are open for visitors, and the open air museum Maihaugen with almost 200 historic buildings is exciting for those interested in culture and history.

Lillehammer is easily visited by taking a northbound train along the Mjøsa from Oslo Airport,the train ride lasts about 1h 45min and departs once every hour. Lillehammer is also reached by the southbound train from Trondheim, a scenic trip which takes about 4h 20min.

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