Designing Multi-modal Interfaces for Demanding Conditions in Crisis

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CS-E4002: Human-Centred Research and Design in Crisis

Aalto University

Lecturers

Jari Laarni, Principal Scientist, VTT

- PhD (psychology, cognitive science)
- Key qualifications: Human Factors Engineering processes; Human Factors Engineering Program development; Control room design; Training program development; Verification and validation of control room design; Job design and task analysis; Cognitive ergonomics; Cognitive modelling
- Over 25 years of experience in Human Factors/User-centred design

Paula Valkonen, Doctoral Candidate, Aalto university

- Doctoral studies in Aalto university, department of Computer Science since 2007 (1: User-centered concept design of wearable electronics in challenging operation environments. 2: eHealth services as a part of Chronically Ill Older Adults´ Patient Experience)
- 15 years in User Experience/User research/Service design consulting business
- Special interests: challenging operation contexts and user research methods, investigation of user needs, concept design, wearable electronics, older adults, eHealth

Schedule, 30.6.2020 at 17.15-18.45

17.15-18.00 Users in demanding operation conditions (Jari Laarni)

- Demanding operation conditions (work environments, disasters, extreme sports)
- Working in demanding operation conditions
- Human in demanding operation conditions – psychological perspective

18.00-18.30 How to investigate user needs in demanding operating conditions? (Paula Valkonen)

- Experiences and tips to share
- Methodology perspective (cases: Firefighter, Visually impaired)

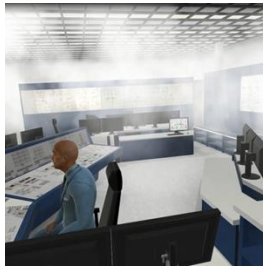
18.30-18.45 Discussion

User in demanding operation conditions

Some examples of demanding and adverse operational environments

Demanding work environments

Nuclear



Military

Extreme sports

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Disasters

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What is common to and what is different between these cases?

Write your findings in chat, please.

Key characteristics of demanding/adverse operational environments

Severe consequences are possible:

- Risk of death or severe physical harm
- Risk of natural and economic disaster

High physical and cognitive demands

- Critical personnel has to try to perform at their maximum capabilities – and often for a long period of time

May elicit panic, stress, anxiety and despair

- Some people act in an irrational manner (e.g., lose their control)

Special challenge

Complex user interfaces and/or demanding usage conditions

What domains are these examples coming from?

Write your findings in chat, please.

Some examples of disastrous consequences of problems in human factors

Human factors problems are often (but not necessarily) caused by design flaws
BUT: whatever the truth, operators are nearly always blamed for the consequences.

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Crashes of Boeing 737 MAX aircraft

Poor human – automation collaboration ->
Deficient automation awareness

https://www.quora.com/How-much-did-the-Norwegian-frigate-that-just-sank-cost-in-total
https://www.nbcnews.com/technolog/drones-crash-lot-militarys-safety-lessons-may-help-civilians-1C8932488

Poor situation awareness ->
Poor user interface design

Different forms of stress

Acute vs. chronic stress

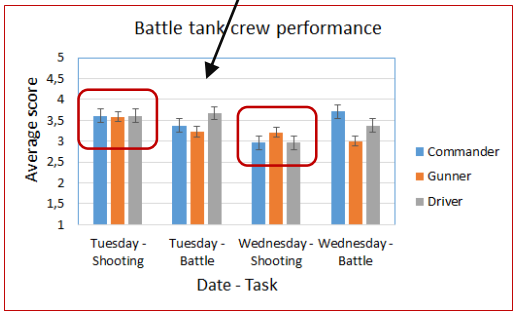
- **Acute stress:** caused by stressors that occur short periods of time
- **Chronic stress:** caused by stressful events that last over for long period of time

Causes of acute stress

"Normal" life events vs. states of emergency

- **"Normal" life events:** fear of public speaking, fear of examination, simple phobias, sleep deprivation etc.
- **States of emergency:** victim of robbery, car accident, fire, earthquake etc.

Performance deteriorated due to sleep deprivation



How we react to acute stress in emergency situations?

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IRRATIONAL FIGHT ⟷ IRRATIONAL FEAR

Irrational fight: counter-attack

Irrational flight: trying to flee from the situation

↓

PARALYSIS

Paralysis: we freeze and cannot move and/or think

Fear, physiological arousal and performance

Conditions White, Yellow, Red, Grey and Black

Heart Rate	Physiological Reaction
60 BPM	
80 BPM	Normal resting heart rate
90 BPM	
115 BPM	Fine motor skills deteriorate
120 BPM	
145 BPM	Complex motor skills deteriorate
150 BPM	
175 BPM	Cognitive processing deteriorates
Above 175 BPM	Irrational fight or flee

Complex motor skills at the optimal level
Reaction time at its peak

Freezing, reduced bleeding, tunnel vision, auditory exclusion etc.

(adapted from Dave Grossman (2008) On Combat. Warrior Science.)

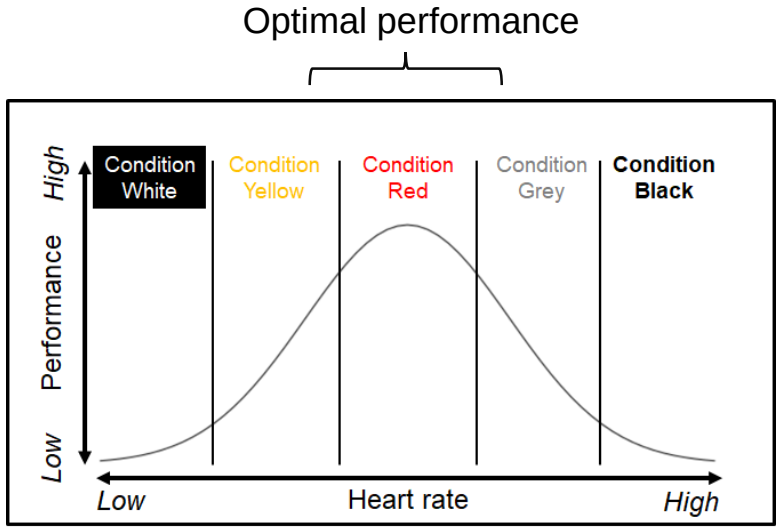
Perceptual and cognitive distortions

Diminished sound
Intensified sounds
Tunnel vision
Heightened visual clarity
Slow motion time
Temporary paralysis
Automatic pilot ("scared speechlesness")
Memory loss for parts of the event
Memory loss for some of your actions
Dissociation
Intrusive distracting thoughts
Memory distortions
Fast motion time

(adapted from Dave Grossman (2008) On Combat. Warrior Science.

Stress and performance

Yerkes-Dodson law:

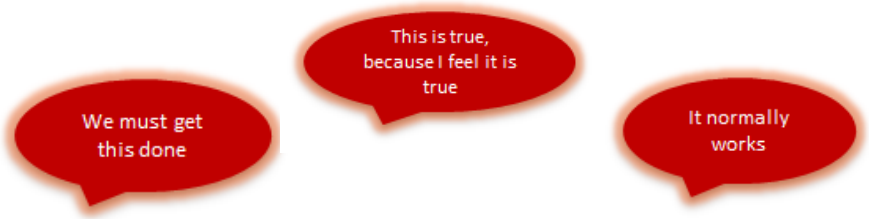


Decision making under stress

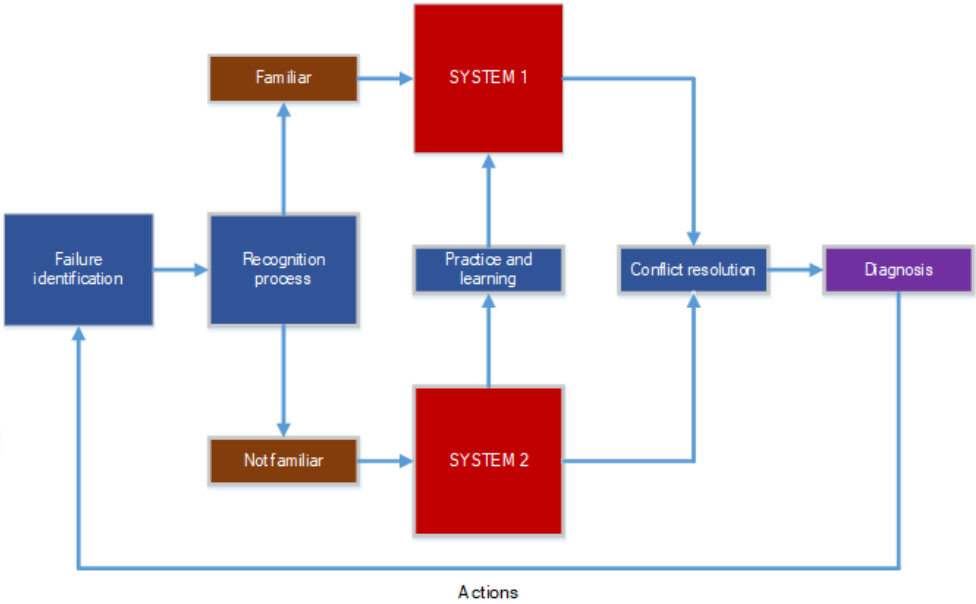
Under stress System 1 takes the reins

-> black and white decisions

-> vulnerability to cognitive biases



"Fast and furious", skill-based, jumps quickly to a conclusion



"Slow and lazy", reflective problem solving

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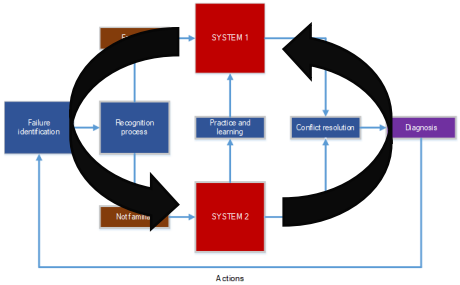
(modified from Croskerry, P. (2009). A universal model of diagnostic reasoning. Academic Medicine 84, 1022-1028.)

Designing for demanding operative environments

GOAL: Flexible use of System 1 and 2



LEADING TO: Behavioural resilience

CHALLENGE: how we support it with design aids?

How to investigate user needs in demanding operating conditions?

Experiences and tips to share 1/2

Keep an eye at least on the following things:

- When working in teams – how the help in situation awareness building and how to share information
- Honor the hierarchies – it saves lives
- Hands are often full of items – do not make more load to them
- Lack of senses – what senses are available and could you for example build an interaction based on many senses?
- Don´t add yourself in danger – use simulations and reconstructions to gathering information

Experiences and tips to share 2/2

Keep an eye at least on the following things:

- Don´t introduce more hazards to your potential end-users when observing – take care of distance and don´t disturb the end-users in their work. Sometimes the results a poor viewing position, so seek actively alternative ways to collect your data.
- Organize always a backup system to your preliminary system. Anyway, your system must be reliable.
- Prioritize information offered in the UI – but do that in co-operation with users.
- Cherish ergonomics! Take note of the whole life cycle and make sure the ergonomics in all phases.
- Work modeling is valuable because so it can be used for risk management or recognition of risks when designing complex systems. Be systematic: use cognitive task analysis, task analysis, functional analysis or some other of many other options

What if…

Investigating user needs puts you in danger?

Case 1: Firefighters at work






Challenge: What do you note of the use context based on the photos?

Write your findings in the chat, please.

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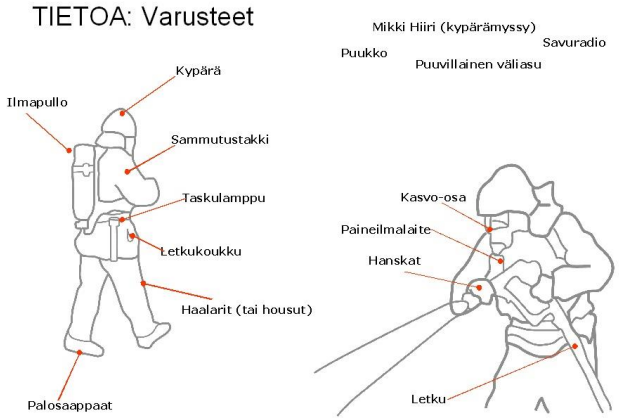
Case 1: Firefighters at work

Some facts of the firefighters

- Working in teams, including pairs
  - Information of the own pair and other team members important
- Wearing protective clothing and equipment
- •Hands are often full of tools, machines, and water pipes.
- Examples of the time limitations
  - to get the water from water pipe - in 2 mins
  - to cut a crashed car´s roof away in an accident situation – max 20 mins
  - Smoke diving – max 15 – 20 mins
- Work hierarchy helps and saves lives



Challenge: From a design perspective, how would you help a firefighter to get information outside of the building when you are in, and vice versa?

Write your findings in the chat, please.

Case 1: Firefighters at work

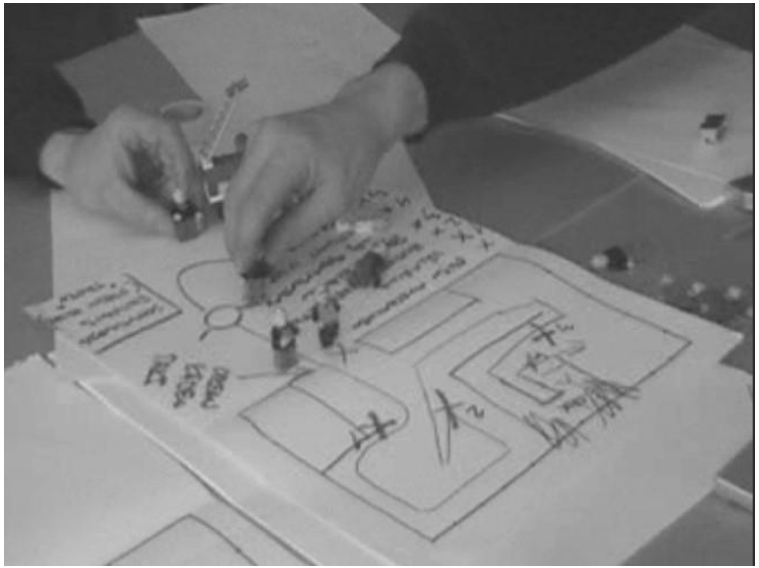
Challenge: You should develop an information-sharing concept to firefighters. How would you investigate of firefighters…

- What tasks firefighters have in their work?
- What equipment firefighters have?
- How do they communicate together?
- What information needs firefighters have?
- When a task is successful?

Write your ideas down in the chat, please. 5 minutes!

Methodology perspective: Case Firefighters

- Observations in almost-real-simulation – situations. Like training exercises: we visited in examination test of Emergency Services Academy of Finland.
- Role play and scenario-based methods, like storyboards, to investigate use context and information needs
- Retrospective interviews to investigate end user´s real use situations and gathering user needs



What if…

Either the user lacks senses, or the environment makes that to the user? How to take this into account?

Case 2: Visually Impaired

- **Everybody of us can sometimes have a lack of some of our senses – temporarily – because of the qualities of environments.**
  - In a noisy environment it is challenging to hear
  - In a dark or very bright environment it is challenging to see
  - When wearing a lot of clothes in the winter it is challenging to feel
  - Etc.
- **Lack of some senses long-term, examples:**
  - Visually impaired
  - Deaf
  - Worker with safety clothes…

Challenge: What qualities of things a visually impaired appreciates?

Write your thoughts in the chat, please.

Case 2: Visually Impaired

Some facts of the visually impaired

- Haptic experience is important – experience does not include visuality at all – different visuality than among seeing people.
- Lack of seeing affects strengthening of other senses –different ability to understand distances and using hearing to that.
- Hands full of equipment (a white stick, a guiding dog…)
- When moving often in a danger (street maintenance, stairs, metro doors (or the space between two metro carriage) – home environment includes risks, too (knives when emptying a dishwasher…)
- Heterogenous group of people – a large variety of needs and wishes, earlier experiences, tastes

Challenge: From a design perspective, how would you gather information about visually impaired people to empathize with the end-users?

Write your findings in the chat, please.

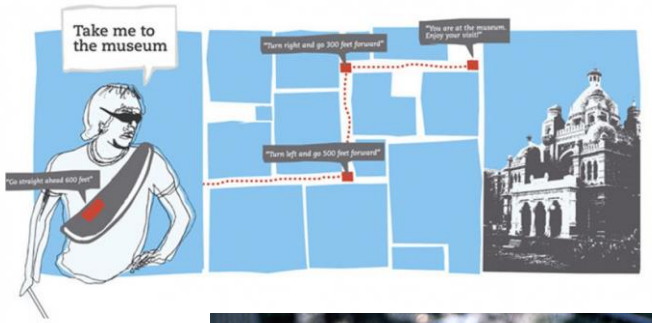
Methodology perspective: Case Visually Impaired

- Experience prototyping and self-diary to gathering own experience to designer
- Surprising fast to get other senses to work when spending time eyes covered!
- Contextual inquiry to investigate use context and to understand how orientation – visually impaired way to find in the right place – works and what should be taken account
- Group interviews in gathering a large variety of user needs and to test ideas.

“How do I find my black t-shirt?”

“Auts! That hurts!”

//MUKANA – a guiding smart garment to visually impaired



Top Nominee in INDEX 2007 design competition
Team: Paula Valkonen and Ville Tikka (and the best co-operation partners: Tatu Marttila, Saara Lepokorpi, Eerika Valkonen)

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Discussion

Literature tips

Firefighting

Parker, R., Riley, D., Pearce, G., & Anderson, S. (2007, July). Measurement of Rural Firefighter Productivity & Workload. The Tassie Fire Conference, Wrest Point Conference Centre Hobart, Tasmania.

Denef, S., Ramirez, L., Dyrks, T., & Stevens, G. (2008, February). Handy navigation in ever-changing spaces: An ethnographic study of firefighting practices. In *Proceedings of the 7th ACM conference on Designing interactive systems* (pp. 184-192).

Valkonen, P., & Liinasuo, M. (2010, October). Role playing with fire fighters: using a worst case scenario and verbal re-enactment in the role play. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries* (pp. 805-808).

Other demanding environments

Aaltonen, I., & Laarni, J. (2017). Field evaluation of a wearable multimodal soldier navigation system. *Applied Ergonomics 63*, 79-90.

Bergroth, J., Koskinen, H., & Laarni, J. (2018). Use of immersive 3-D virtual reality environments in control room validations. *Nuclear Technology, 202*, 278-289.

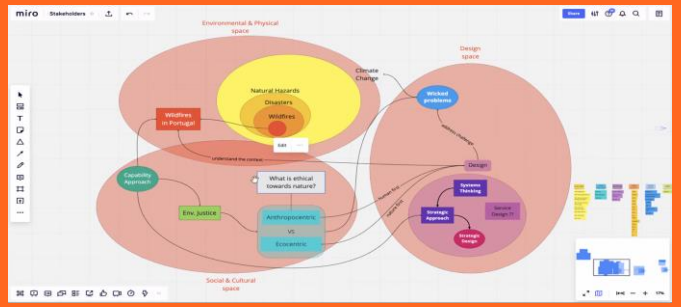
Laarni, J., Pakarinen, S, Bordi, M., Kallinen, K., Närväinen, J., Kortelainen, H., Lukander, K., Pettersson, K., Havola, J., & Pihlainen, K. (2019). Promoting soldier cognitive readiness for battle tank operations through bio-signal measurements. In: *Proceedings of AHFE'2019*. Springer.

Pakarinen, S., Korpela, J., Karvonen, H., & Laarni, J. (2019). Modeling the cardiac indices of stress and performance of nuclear power plant operators during simulated fault scenarios. *Psychophysiology*, [e13513].

Participatory Workshop 2: Mapping Ecologies of Crisis using Design Thinking

Prof. Nitin Sawhney
Department of Computer Science, Aalto University
André Santos, *PdP Course Coordinator, Aalto Design Factory, Aalto University*

Friday, July 3, 10:00 - 12:00



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