Teaching sterile skills in anesthesia
Is providing context helpful for robust skill acquisition?

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Epidural anesthesia
- Relaxed relief method during childbirth and during and after operations
- As it is an invasive technique, it carries the risk of contamination
- Residents basically learn the procedure in the clinic
- Even after 4 years of training, residents still make sterility errors (Friedman et al., 2008)
- Sterility is a complex concept
- Sterility is not visible

Present training is not optimal
- Medical skills should be flexible and robust (Cnossen, 2015)
  - Flexible: applicable outside context in which it was learned
  - Robust: resistant to stress and workload
- Present training of complex procedures often focuses on the order of the steps of the procedure
- This makes learning vulnerable
  - Steps may be forgotten and skipped
  - Steps may be performed in the wrong order
- In practice there is no fixed order of steps
  - Different procedures have different steps, equipment, medication
  - Not all steps have to be performed in a strict order
  - In practice, every supervisor has their own preferred order and method
- Focus on the steps in the procedure during learning
  - Does not lead to flexibility in the skill
  - What if a step cannot be performed
  - Does not lead to robustness of the skill
  - In stress situation memory errors can happen

Different approach: focus on the context
- Taatgen, Huss, Dickison & Anderson (2005) showed that in teaching flexible cognitive skills teaching materials should draw attention to
  - The pre-conditions of actions (knowing when)
  - The post-conditions of actions (knowing the effects of actions in the environment)
- They found that Boeing pilots were more flexible and the skill was more robust after learning with a focus on these environmental cues
  - Learners can then rely on environmental cues rather than keeping track of all the executed steps in their mind
- We applied this approach to training preparing and executing epidural anesthesia

Method
- 37 medical students participated in simulation study
- Skill preparation of epidural anesthesia
  - 14 steps
  - 10-15 minutes
- Procedure
  - Video instruction of procedure
  - Studying description of steps on paper
    - Non-sterile actions were written in red
    - Sterile actions were written in green
  - 15 minutes practice with materials and instruction sheets
  - Test: perform the procedure with an "non-sterilising nurse"

Instructions
- List condition
  - 34 steps in chronological, strict, order
- Context condition
  - 34 steps arranged in sets
  - Order within set was not important
  - Photographs
  - Pre-conditions of a set of actions ("before")
  - Post-condition ("after")
  - Description of the actions to be performed within the set

List Condition
- R. Kremersten
  - Je eet Steriel Maken:
    - 7. Desinfecteer je handen
    - 8. Trek de steriele jas aan
    - 9. Trek de handschoenen aan
- Standaard voor bereid maken van een epiduraal noodtoestand
- Context Condition
  - Material Op Tafel Positioneren:
    - 10. Pakken in blauwe bak
    - 11. Kleine bakje boven epiduraalnaaldset
    - 12. Grote bakje, voor roze Chlorhexidine, in andere bovenhok
    - 13. Geef de gat-dief met de 7 mathematical

Main results
- Sterility errors
- Order errors
- Clinically relevant errors

Discussion
- Contrary to expectation the context condition did not result in robust skill
  - This stands in contrast to Taatgen et al's study
- Context condition even resulted in more sterility errors than the list condition
- Why?
  - Environmental cues
    - In epidural anesthesia procedure, there are also many environmental cues in list condition
    - Boeing pilots used complicated system with low usability, so possibly profited more from context
  - Memory load
    - Context condition possibly imposed larger memory load on participants
    - The known advantages of the context method were at least partly offset by the disadvantages of this high memory load
- Sterility
  - Apparently, sterility errors are difficult to prevent.
    - Even though we explicitly noted which steps of the procedures were sterile or not
  - The participants in the experiment were probably unfamiliar with the concept of sterility
- Sterility is a complex concept
  - It is not obvious for example that crossing a sterile workspace with (unsterile) bare underarms is not sterile

Conclusions & recommendations
- Complex medical skills involve many steps and induce a high memory load to learn them
  - Providing context when teaching a procedure may therefore not necessarily lead to better skill acquisition than learning the steps
  - But the resulting skill may be more flexible and robust after context-learning
  - Further research is needed to test whether it may be advantageous to first study the steps in a procedure until all steps are remembered before performing the skill
  - Separating studying the declarative knowledge from the procedural skill
  - We can then also test the flexibility and robustness of the skill
- Further research is needed to test whether teaching sterility concepts separately from the procedure itself is needed

References