Resilience / Expertise and technology

The case of robotic surgery

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Resilience
- System’s capacity to cope with disturbance and « surprises »
- Coping with surprises requires some inhibition of routine responses, and flexibility
- Flexibility : capacity to switch strategies

Expertise
- Acquired in a specific domain
- Creates automated responses, routines
- Prone to fixation errors
- Routine (domain specific) / transversal (cross domain) expertise

How do technologies support or inhibit flexibility?
Context of the research

From open surgery to robotic surgery
Open Surgery

- Incision through healthy tissue, which is made large enough to expose the organ to be operated on the surgeon’s eyes and hands
- Direct three-dimensional (3D) view of the surgical site
- Great freedom to approach the organ in a versatile manner for optimal perception
- Tactile and force feedback
Minimal invasive surgery
Laparoscopic Surgery

Advantages

- Very small incisions
- Smaller risks of infections
- Reduction of post-operative pain
- Fast recovery
- Higher accuracy due to operation scene magnification by the camera
Laparoscopic Surgery

Disadvantages

- Indirect and restricted view of the surgical site
- Rupture of the axis motor/perception
- Only visual feedback
- Image in 2D
- Degree of freedom for instrument movements restricted
Robotic surgery

- Remote surgery
- Only visual feedback
- 3D view (2D+)
- Still indirect and restricted view of the surgical site
Other advantages

- Removes the inherent tremor of the surgeon’s hand
- Decreases the movement amplitude in case of error
- Increases the degree of freedom for instrument movements
Is the system robust to disturbances?

- **Field study**
  - Comparison between classical and robotic laparoscopy
  - Observation and recording of all communication content between surgeons

- Use communication as a sign of adaptation demands within the surgeons’ team

- **Assumptions:**
  - the more communication used within a team, the more real time adaptation (RTA) needed
  - the more RTA needed, the more “artificial” - and the less robust - the system
Surgeons’ communication classification

7 types of communication content

- Orientation
- Manipulation
- Strategies
- Order
- Confirmation
- Relaxation
- Stress
Robot-surgeons system’s performance

- Average operation quality is better but...
- Operation duration increases with the robot
- More acts of communication with the robot:
  - Orientation
  - Manipulation
  - Orders and confirmation
- Verbal communication as an adaptative process to compensate the non verbal communication (loss of face to face)
Is the robot-surgeons system’s robust to surprises?

- 4 reconversions observed during the study
- Reconversion:
  - Change of surgical strategy
  - From robotic to laparo or open surgery regarding the type of surgery
    - Digestive surgery -> laparo
    - Cardiac surgery -> open
- Implies an instrumental Switch and sometimes a perceptive Switch (from 3D to 2D)
- Decisions taken by the surgeons when confronted to a patient presenting an “anomaly” of anatomy
How does the robot-surgeons system adapt to surprises?

- Back to classical expertise and classical man-machine system
- Increase of verbal communication during reconversions
  - Strategies
  - Orientation
  - Manipulation
  - Order but not confirmation
  - Stress
- Verbal communication pattern shows “emergency adaptation” process
- Classical expertise needs to be available!
What if there is no « classical » expertise?

Simulator study

Protocol

- 40 medical students performing a task in 4 conditions:
  - classical laparoscopy 2D
  - classical laparoscopy 3D
  - robotic surgery in 2D
  - robotic surgery in 3D
- 6 trials in one condition
- Perceptive switch: 2 trials
- Technical switch: 3 trials
- Task: rings route

Classical laparoscopy
direct view (3D) or Screen (2D)

Robotic surgery
2D ou 3D view
Learning curves and switches

**Perceptive switch (6-7)**
- 3D>2D whatever the technique used
- In 3D view, similar curves with the two technologies
- In 2D view, curve with the robot > curve with the classical laparoscopy
  -> In 2D, instrumental dimension influences the performance

- Very strong impact of perceptive switch (6-7)

**Instrumental switch (8-9)**
- Very strong impact of technical switch (8-9): same performance than on the 1s trial!
  - no evolution for laparo 2D condition: there is no transfer of skills from robot to laparo
  - learning with robot seems to impair learning with laparo
Conclusions

- Robotic surgery is “robust yet brittle”
  - Robust to surgeons’ tremor
  - Brittle to patients’ anomalies

- Dealing with surprises = back to classical surgery, classical expertise

- Back to “Ironies of automation”, Bainbridge
  - Robot designed and used for normal situations (daily)
  - Flexibility required from humans (for exceptions):
    - Under surprising and difficult (emergency or abnormal) situations
    - Under high stress
    - Calling upon less practiced “classical surgery” skills

- Very strong impact of classical surgery skills availability to maintain performance under surprising conditions

- Diversity in expertise (classical, laparo, robot) required for system’s resilience

- How to keep “jurassic skills” alive, for how long and how to generate them to novices?
  - Mandatory recurrent practice with “old” technology?
  - Simulation?