



# Supporting anaesthetist situation awareness: New tools, new challenges

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# Acknowledgments

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  - Dr W John Russell, Dr Simon Jenkins, Dr Kristen Llewellyn, RAH
  - Associate Professor Marcus Watson, UQ
  - Dr Norris Green, PAH
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- Staff of Skills Development Centre, Queensland Health.

# Patient safety and equipment interface

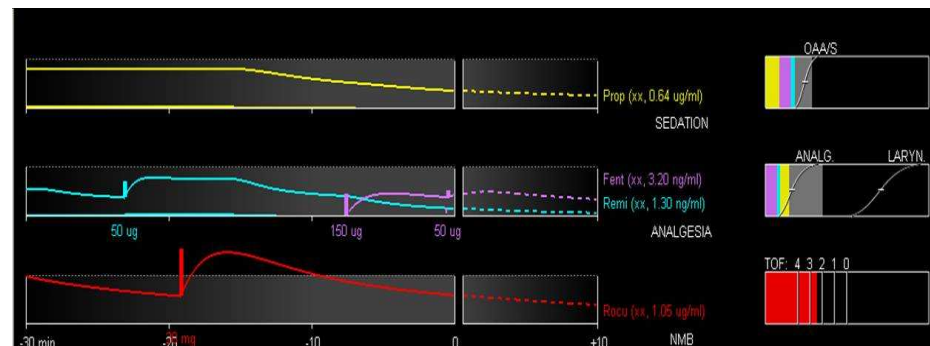
## Examples

- Are products safe and effective?
  - Abbott Lifecare 4100 PCA interface led to morphine overdoses and deaths. Lin et al. (1998) *J Clin Monit Comput*
  - IEC60601-1-8 alarm standard recommends radical changes to alarms without user evaluation. Sanderson et al. (2006) *Anaesthesia*
  - Novel visual interfaces for drug delivery systems. Drews et al, (2006) *Hum Factors*

Abbott Lifecare  
4100 PCA



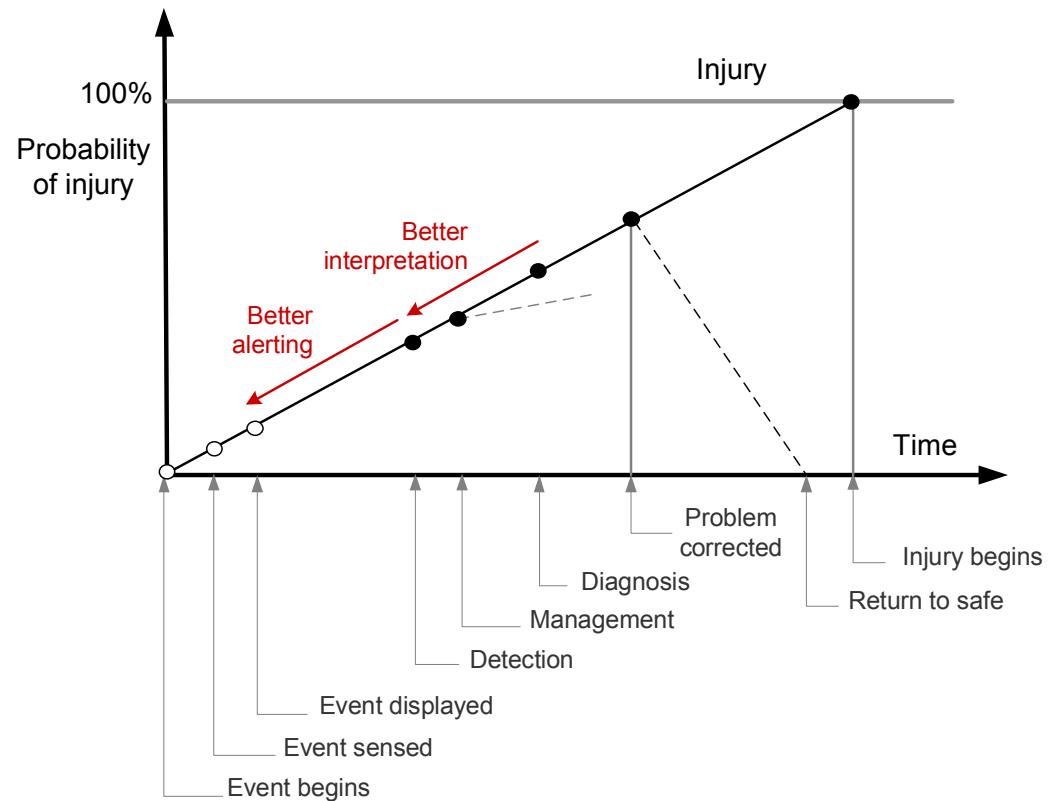
Drews et al (2006) Drug delivery visualization.



# Removing paths to harm: Patient safety during patient monitoring

- Designing and evaluating patient monitoring displays to reduce probability of injury.

Kerr (1986) *BJA*  
Zhang et al (2000) *Cogn Tech Work*  
Schreiber & Schreiber (1989) *J Clin Monit Comput*



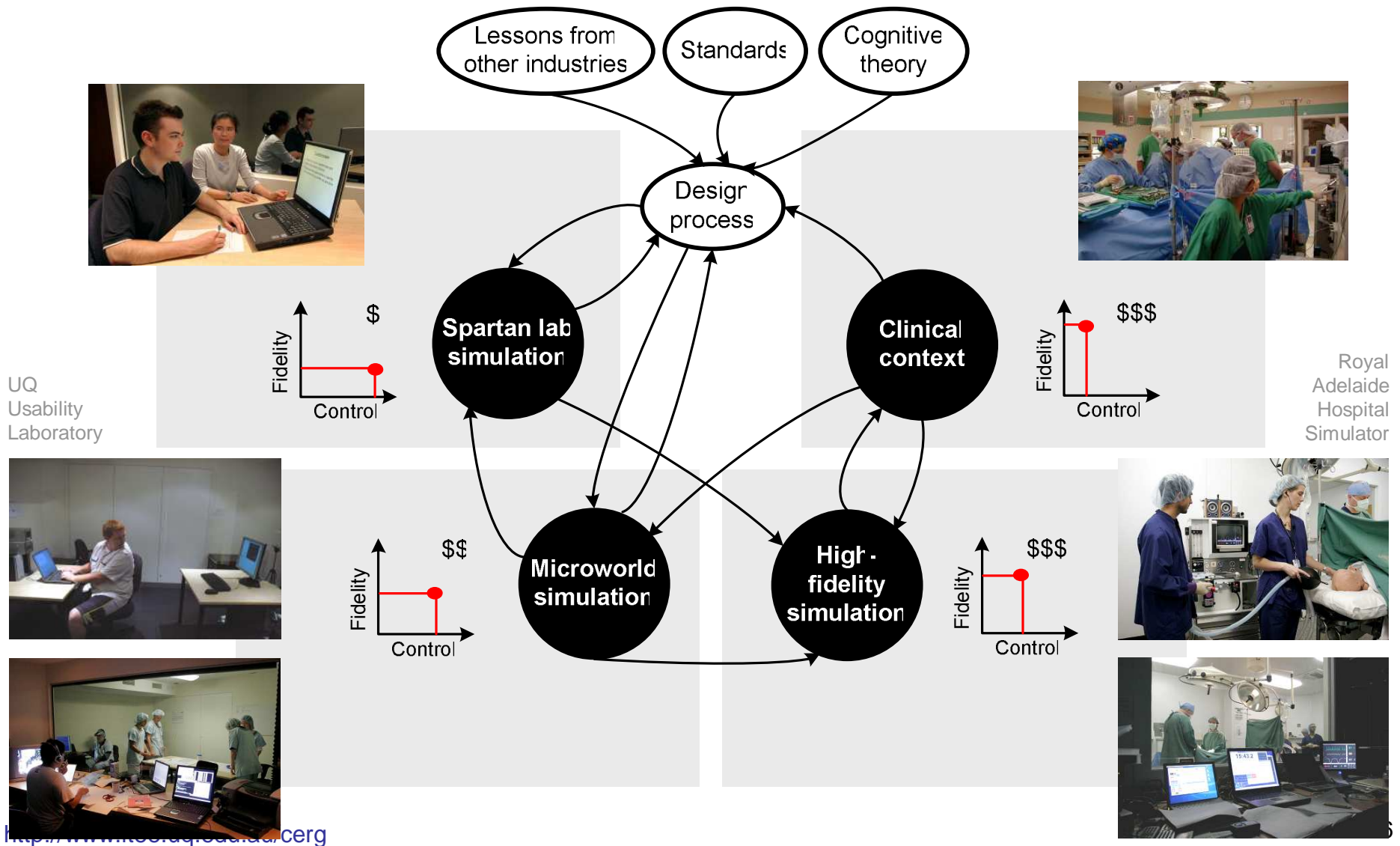
# Advanced monitoring displays

## Concepts to improve patient safety

- **Respiratory sonification** Watson & Sanderson (2004) *Hum Factors*
  - Breath cycle: inspiration=high note, expiration-low note
  - ETCO<sub>2</sub>=absolute pitch of inspiration:expiration notes
  - Tidal volume=volume of sonification
- **Blood pressure earcons** Watson & Gill (2003) *Proc OzCHI*
  - Two notes indicate normal systolic and diastolic pressures
  - Two following notes indicate just-measured systolic and diastolic pressures
- **Head-mounted displays** Ormerod et al, (2002) *Proc STA*; Via et al., (2003) *Proc STA*
  - Vital signs and waveforms.



# Human-centred design and evaluation: Research environments for testing



# Study of advanced displays: Experimental design

- What are the relative merits of head mounted displays (HMDs) and advanced auditory monitoring (Sonification) for patient monitoring by a distracted anaesthetist?
  1. Visual monitor/PO only
  2. HMD + Visual monitor/PO
  3. Sonification + Visual monitor/PO
  4. HMD + Sonification + Visual monitor/PO
- 22-minute scenarios with four unexpected events
- Participants read and classify anaesthesia abstracts while supervising anaesthesia registrar
- All participants (N=16) experience all monitoring conditions, orders counterbalanced.



# Study of advanced displays: Scenarios

- All scenarios had four events occurring at tightly controlled times

## Patient scenario A

- 1 (E) Oesophageal intubation
- 2 (UE) CO2 line.....and again (2 events)
- 3 (E) Ventilator overpressure

## Patient scenario B

- 1 (E) Surgical stimulus
- 2 (E) Drug overdose
- 3 (UE) Y-piece disconnect (2 events)

## Patient scenario C

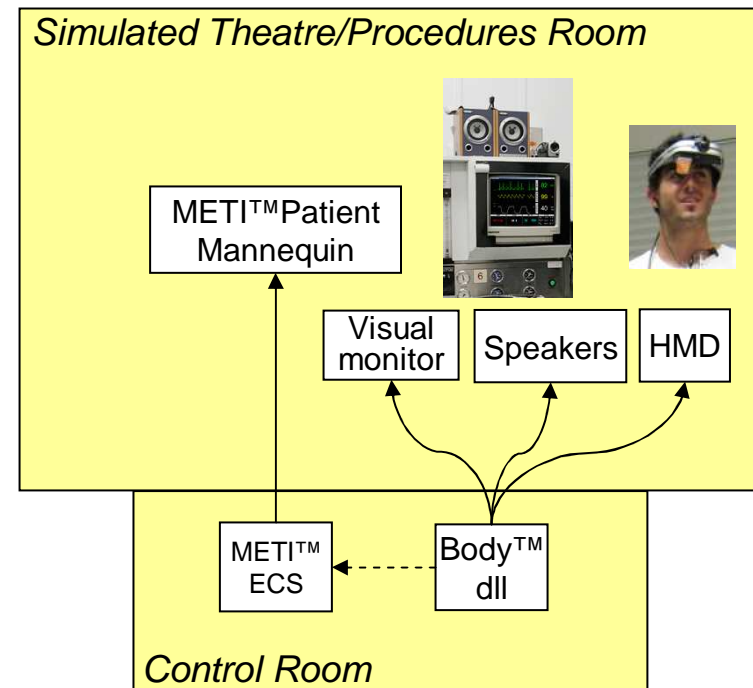
- 1 (E) Ventilator not switched on
- 2 (E) Breathing against ventilator
- 3 (UE) Gas embolism treated as fluid loss (2 events)

## Patient scenario D

- 1 (E) Airway obstruction: Reposition LMA
- 2 (UE) Excessive volatile gas? (2 events)
- 3 (E) CO2 line disconnection

# Study of advanced displays: Need for technical innovation to run study

- Precise control of respiration in highly specific scenarios
- Run METI™ ECS and Body™ software in parallel
- Mannequin events consistent with Body™ events (breathing, eyes, etc)
- No participants appeared to realise simulation was non-interactive.



# Study of advanced displays: Simulator layout at RAH



HMD and headcam



HMD overlay



- Control room with METI™ and Body™ running in parallel
- OR with Vm/PO, auditory displays, and HMD.

# Study of advanced displays: Data collection



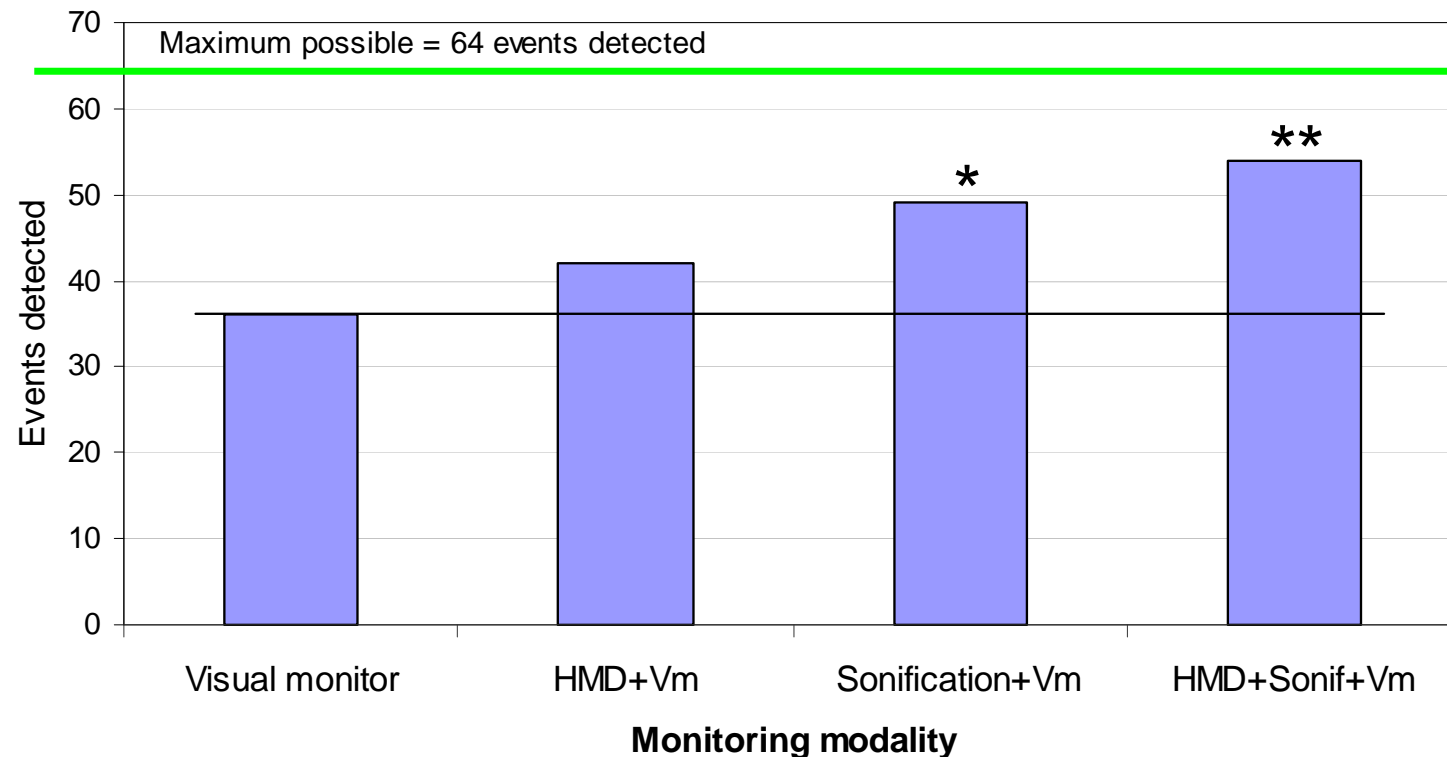
All normal—anaesthetist reads abstracts and is content to let junior colleague proceed.



Changes heard in vital signs—anaesthetist turns to supervise junior colleague more closely.

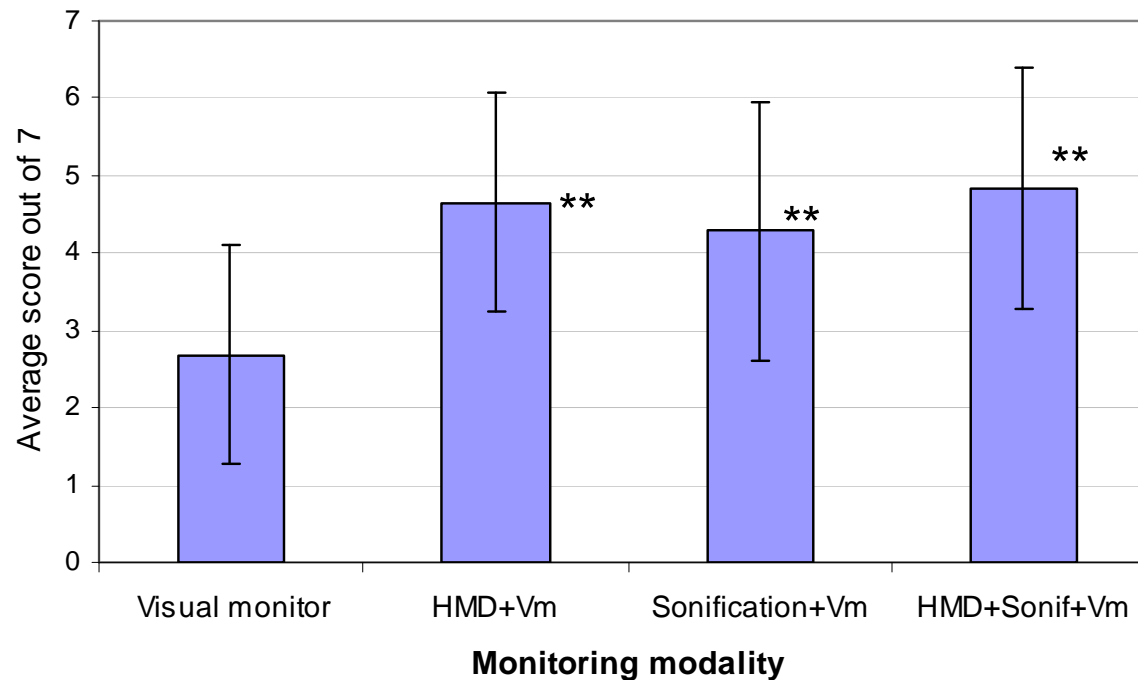
# Study of advanced displays: Preliminary results

- Number of events detected overall in each monitoring modality condition—sonification seems *necessary* for better performance.



# Study of advanced displays: Preliminary results

- How easy was it to monitor the patient with the monitoring modality just used?



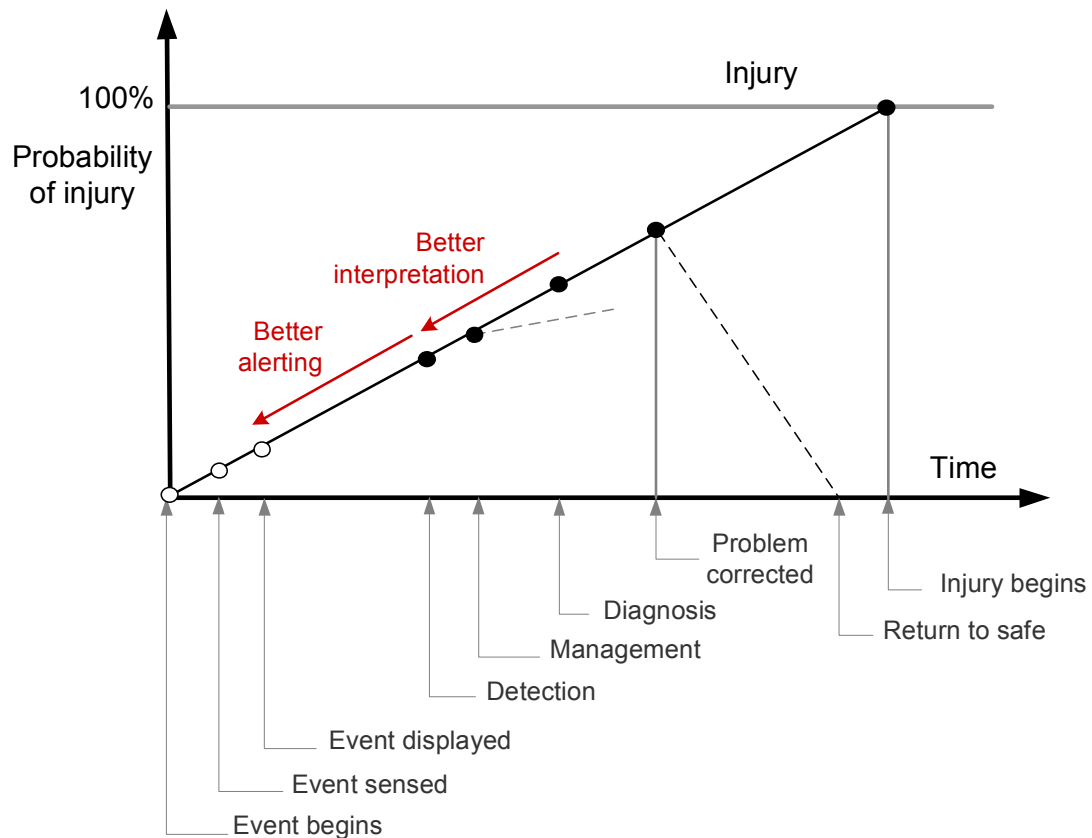
- Empathic personalities more likely to report that auditory displays make monitoring easier,  $r=0.76$ , and faster,  $r=0.65$ .

# Study of advanced displays: Subjective feedback

- Respiratory sonification
  - 63% - like speed of getting information
  - 31% - no dislikes expressed
  - 56% - express concern with extra noise in OR
- Blood pressure earcons
  - 50% - like alert to BP reading and getting info
  - 44% - like getting BP info this way
  - 38% - no dislikes expressed
  - 44% - dislike transience of the information
- Head-mounted displays
  - 81% - like convenient availability of patient information
  - 56% - dislike weight/bulk of HMD unit
  - 31% - dislike moderate visual interference

# Study of advanced displays: Outcome for patient safety

- Examine how well people perform as well as their subjective judgment of novel medical equipment



# Implications for patient safety

- Simulators can help develop and evaluate healthcare equipment
- Sometimes need technical innovation to test novel equipment or displays.
- Easy to get to a basic and useful level of proficiency with advanced monitoring technologies tested
- Still to be explored:
  - Training required for fullest understanding?
  - Impact on team coordination?
  - Best use in crisis management?
- Possible changes needed to ACRM programs.



END

COMBO1 team  
(Drs W John  
Russell and  
Kristen Llewellyn  
absent) RAH, 2006

# Experiment on advanced displays: Scenarios



Parallel simulation technique developed by Simon Jenkins and David Liu



Early versions of scenarios developed by Sanderson, Russell, Jenkins, and Watson, then refined with Norris Green, and finally implemented by Liu, Cole, and Watson.



# Uses of high-fidelity simulation

- Skills, training, and risk
  - Education and training
  - Crisis management
  - Risk evaluation
  - Incident investigation
  - Assessment of performance
- Human-system integration
  - Pre-purchase equipment evaluation
  - Inservice training effectiveness
  - Design and evaluation of procedures and protocols
  - Evaluating workload and fatigue
  - Organisational simulation—workflow, communication
  - Design of human-system interface via R&D partnerships



Dalley et al. (2004) *Anesth Analg*  
Smith & Gaba (2000) In *Clinical Monitoring: Practical Applications*.