Limits to Audible Alarm Signal Recognition when Encoding Alarm Context
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Audio Alarm Signals and Context

- Encoded a good degree of context in 17 different audio alarm signals
- 2 yrs. later assessed their discriminability
- Sources for the 17 signals included:
  - Nurse call system
  - Physiologic monitoring system
  - Not vents or pumps
  - Wireless phones
  - Pagers
Discrimination Test

- **Participants**
  - 25 CVSICU RNs, 3 levels experience
  - No screening for hearing ability/loss

- **Protocol**
  - One session recognition testing with 3 trials, each presenting 17 tones randomly
  - .wav files via headphones
  - Each signal balanced for volume
  - Each signal presented for 10 sec
  - Responses recorded as correct/incorrect
Results: Recognition Accuracy

- Patient normal (Nurse call) 100%
- Voice call (WiFi phone) 100%
- Crisis (Monitor) 84%
- Code blue (Nurse call) 67%
- Code blue/Lav emerg, etc. (WiFi phone) 67%
- Equipment disconnects/text msg (WiFi phone) 67%
- System warning (Monitor) 67%
- Advisory (Monitor) 65%
- Lav assist (Nurse call) 63%
Results Continued

- Crisis (Pager) 60%
- Non-crisis (Pager) 59%
- Warning (Monitor) 48%
- Equipment/vent alarm (Nurse call) 21%
- System advisory (Monitor) 15%
- Staff and Lav emerg (Nurse call) 13%
- Staff normal/Equip disconnect (Nurse call) 3%
- Staff & Pt normal/Lav assist (WiFi phone) 0%
• Discriminable differences in intensity, pitch, beats and harmonics **shall** be provided.

• Audio warning signals **should** normally consist of two elements: an alerting signal... and an identifying or action signal

• If absolute discrimination is required, the number of signals to be identified **shall not** exceed four
IEC 60601-1-8

- Alarms **should:**
  - Help determine urgency
  - Locate the room/patient
  - Determine or categorize the cause of the alarm condition
  - Determine or categorize the nature of response or awareness required
The goals that any alarm signal should meet include:

– Clearly communicate the appropriate degree of urgency
– Clearly identify the relevant location
– Clearly identify the reason for the alarm condition
Research Points Out

- “People can only differentiate, learn, and/or remember a few different abstract auditory alarm signals” (Stanton and Edworthy, 1999; Patterson, 1982).

- “Medical professionals appear to be poor at correctly identifying auditory alarm signals in their environments”. (Momtahan et al., 1993).

- Fewer than 30% of [non-anesthetist] participants could identify [16 melodic alarms designed per IEC Annex F with] 100% accuracy” after practice.” (Sanderson et al. 2006)
Summary of The Standards

- Discriminable differences **shall** be provided

- “Absolute” audible signals **shall not** exceed four

- Audible signals **should help** determine
  - Urgency
  - Location
  - Categorize cause/reason for alarm condition
  - Response required
What Now?

• Physiologists and clinicians decide on alarms levels and thresholds
• HF and engineers can assist with best use of technology within manufacturers constraints
• Reduce the number of signals/tones
  – Ideally 3 tiers: Run / Walk / Shuffle
• Encode only the highest priority audible alarms with alarm-specific content
• Use other media (visual or voice) to convey context other than urgency
Tone Reduction Plan

• Reduce WiFi phone signals from 4 to 2 tiers of priority (eliminates 2 signal)

• Transfer physiologic monitor pager alarms to existing WiFi phone signals (eliminates 2 signal)

• Combine lav assist call with patient normal call (eliminates 1 signal)

• Disable the hall monitor crisis signals

• Retest
AAMI Alarm Foundation Efforts

- AAMI alarm standards committee recognizes the challenges

- AAMI supporting Judy Edworthy to develop 7-10 signals

- Those to be evaluated by an international work group

- International alarm committee to adopt a set of signals
1. ANSI/AAMI HE75: 2009, Human Factors Engineering- Design of Medical Devices
2. IEC 60601-1-8 General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems
6. Sanderson et. al. (Anaesthesia, 2006, 61, pages 142-147)

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