Cognitive Informatics
Conflict of Interest

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Has no real or apparent conflicts of interest to report.
Maxwell’s Demon

- James Clerk Maxwell was a 19th century mathematician and physicist. He described 'Maxwell's Demon' -- a mythical creature that strives to increase the order of a system (thus decreasing entropy) without a concomitant increase in total net entropy (disorder).

- Although order can be increased in one place for a short period of time, disorder must also eventually increase. Hence, the demon defies the laws of physics.

- This principle of net entropy applies to learning, because the brain operates via rate-limited biochemical and electrochemical functions subject to the laws of physics.
Both active and passive information seeking and information use are modified by cognitive processes and require manipulation of data elements.

How the human brain acquires, processes, and retains information affects the usage of available data, and our reactions to it.

Long-term potentiation (LTP) underlies forming memory and requires brain synapse modification in which a long-lasting enhancement occurs with repetitive stimulation of synapses.

LTP has an early phase of 1–3 hours and a late phase up to 24 hours. Recall & review during these periods aid LTP.

Cognitive Limits

- There are cognitive limits to acquisition of information.
- **Novices** read at a rate no more than 150 words per minute (WPM) for comprehension, and **with high stakes scenarios may read no faster than 50 WPM**.
- Content experts skim and scan at 400 to 600 WPM. Experts can become frustrated with novices and may overlook difficulties encountered by novices attempting to acquire new information.
- Information transfer through an electronic health record (EHR) requires reading, and EHR usage for patient care may be considered a high-stakes task.

Cognitive Load / Memory

- Working memory for active information processing includes both short-term and long-term memory components.
- Acquiring new information is limited to only 5 to 9 separate pieces of new information into short-term working memory at any time.
- Between 2 and 4 of these pieces can be processed simultaneously, and only for a few seconds.
- Almost all of this new information is lost after 20 seconds unless it is refreshed through review.
- Learners may go through multiple cycles of learn forget before the new information gets into working memory.
- Long-term memory supplies immediate access to multiple informational items simultaneously.
Visual Learning

- Most people are visual learners (modes: visual, auditory, reading / writing, kinesthetic) and also multimodal (more than one mode simultaneously), which is NOT the same as multitasking (which really multisequencing).

- The visual mode of learning may have advantages for memory storage.

- Visual long-term memory representations can be detailed. Long-term memory for objects in scenes can contain more information than only the gist of the object.

- Human memory is capable of storing fairly detailed visual representations of objects over long time periods.
Memory Formation and Usage

- There is a 20 minute upper limit to effective short-term memory processing and transfer. Technology, entertainment, and design (TED) talks do not exceed 18 minutes.
- Working memory capacity predicts performance on a wide variety of high-level cognitive measures, but individual differences are determined by attentional control over working memory.
- Low-capacity individuals have more difficulty ignoring distracting information than high-capacity individuals, because they are slower at disengaging attention from irrelevant information.
- Multitasking is multisequencing: more tasks must be performed in shorter sequences, or tasks compete for working memory, reducing effectiveness of working memory applied to each task.
Information Anxiety

- A heavy information load negatively affects performance, whether measured regarding accuracy or speed.

- When information supply exceeds processing capacity, a person has difficulties identifying relevant information, ignores large amounts of information, has difficulties in identifying details, and doesn’t reach a decision of adequate accuracy.

- Information anxiety describes stress caused by the inability to access, understand, or make use of, necessary information.

- A coping strategy for overload is satisficing, taking just enough information to meet a need, rather than being overwhelmed, assuming just enough is good enough.
Exploratory decision-making employs gathering of information from multiple sources and requires careful mental regulation.

Exploitative decision-making may focus on exploiting a single source of information deemed to be high-yield, and employs unconscious habitual mental processing of information.

Gathering or exploiting information represent opposing demands, balancing the desire to select what seems from experience the richest option (exploitative), against the desire to seek a less familiar option that might turn out to be more advantageous (exploratory).

People under pressure resort to magical thinking.
Stress and Memory

- Stress causes dissociation, a lack of connection in a person's thoughts, memory and sense of identity, that disrupts functions of memory.

- Dissociation during a traumatic event disrupts both memory storage and retrieval, and may prevent encoding of threatening, aversive memories protective against “bad” memories.

- Dissociative encoding with incomplete initial processing of the traumatic experience may lead to fragmentation of the trauma memory, linked to the development and persistence of post-traumatic stress disorder.
Cognitive Informatics

- Visual analytics: provide advanced interactive visual interfaces to aid reasoning over, and interpretation of, complex data, to avoid information overload.
- Deep learning: machine-learning algorithms; address constraints of human information processing.
- Application: imaging informatics includes repurposing features extracted from natural images for training, the applying the model to real-world problems.
Information transfer is <100% congruent from presentation to reception. Visual aids promote retention of information. When health care providers speak to patients, 40%–80% of medical information is forgotten immediately, almost half remembered is incorrect, and the more information presented, the lower the proportion correctly recalled.
Focus not only on *what* others think (colleagues/patients) but on *how* they think.

- 95% of mental processing takes place unconsciously.
- Just 5% of most immediate decision-making may be based upon conscious, rational thought.
- Unconscious cues include sights (body language, expressions, signs, symbols), sounds, and smells.
- Think and look at everything from the perspective of your users of information.
Win with Excellence

- Compassion and caring go a long way.
- The health and safety of our patients as well as the women and men who serve and care for them is our foremost concern.