RYERSON UNIVERSITY

# Vigilance

*Alex Ferworn*

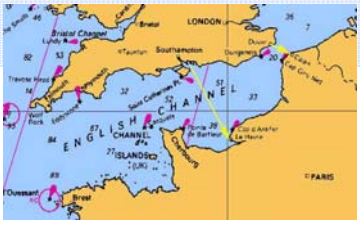
Department of Computer Science

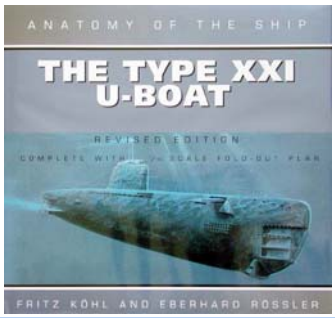
Faculty of Engineering,
Architecture and Science

# Topics

- Historical Background
- Theories of Vigilance
- Enhancing Vigilance Systems
- Automated Vigilance

## Origins of Vigilance Research (1940s)




- German submarines sinking Allied naval and cargo ships in English Channel and Bay of Biscay
- Royal Air Force (RAF) reconnaissance and anti-submarine warfare flights
- Radar and sonar operators on board watching or listening for U-boat contacts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The systematic study of vigilance was initiated by Norman Mackworth during World War II. Mackworth authored "The breakdown of vigilance during prolonged visual search" in 1948 and this paper is the seminal publication on vigilance. Mackworth's 1948 study investigated the tendency of radar and sonar operators to miss rare irregular event detections near the end of their watch.

# Origins of Vigilance Research (Contd.)




- **Low probability of contact**
  - **most missions ended without locating a German submarine**
- **When a contact was missed,**
  - **most often towards the *end* of a flight**
- **False reports--leading to bombing of friendly vessels or large marine life**

# Norman Mackworth's Studies

- Field observations of airborne radar and sonar operators
- Conducted simulation experiments in Applied Psychology with the Clock Test
- Did first laboratory experiments demonstrating the ***vigilance decrement*** phenomenon

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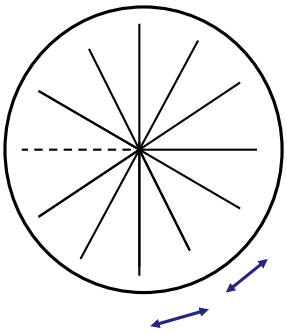
Mackworth simulated rare irregular events on a radar display by having the test participants watch an unmarked clock face over a 2 hour period. A single clock hand moved in small equal increments around the clock face, with the exception of occasional larger jumps. This device became known as the Mackworth Clock. Participants were tasked to report when they detected the larger jumps. Mackworth's results indicated a decline in signal detection over time, known as a vigilance decrement. The participants' event detection declined between 10 and 15 percent in the first 30 minutes and then continued to decline more gradually for the remaining 90 minutes. Mackworth's method became known as the "Clock Test" and this method has been employed in subsequent investigations.

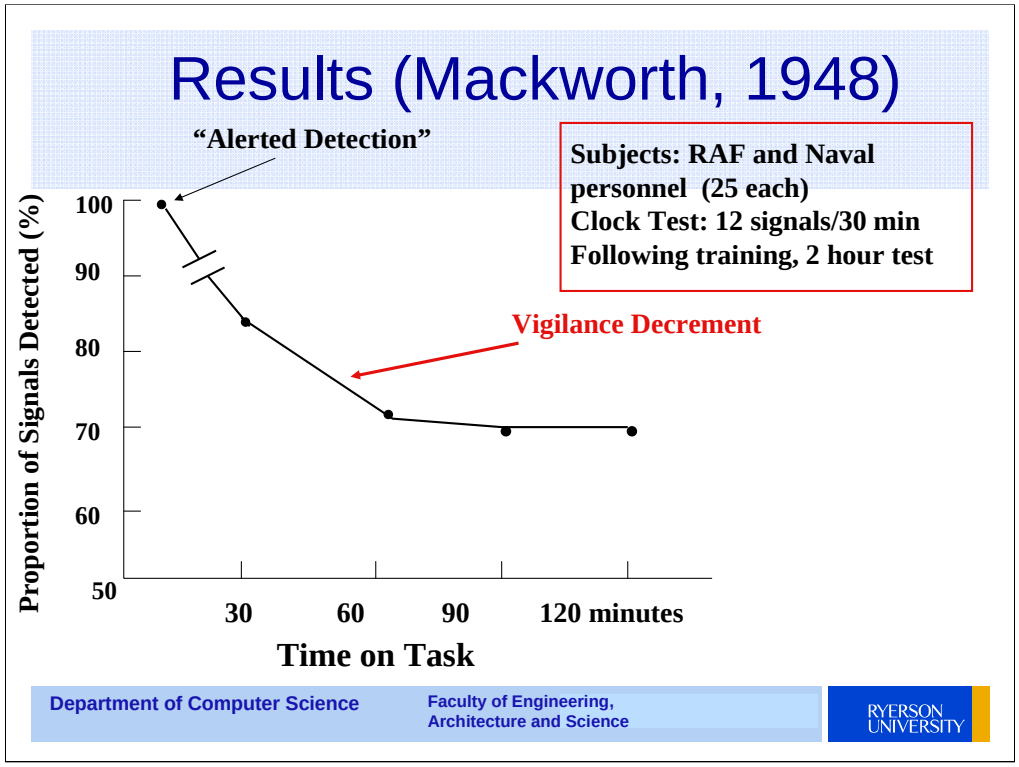
# Mackworth Clock Test

**Double Jump = Signal**

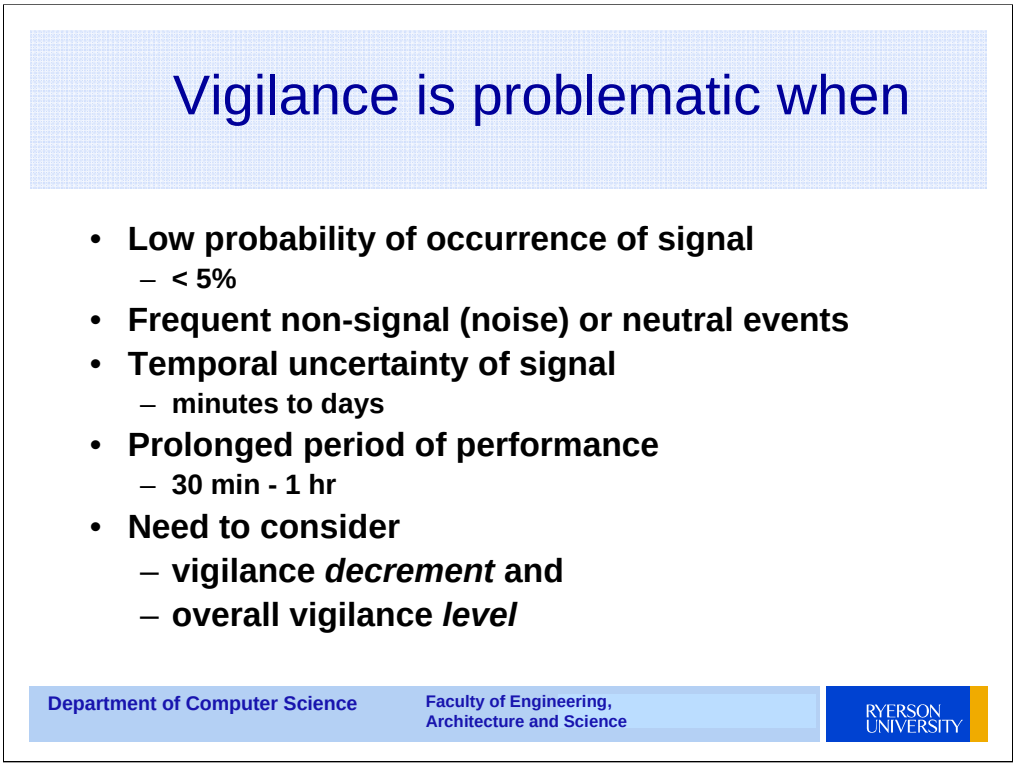


**Single Jumps = Neutral events**

***Signals occur unpredictably and infrequently (12 every 30 minutes)***




Vigilance decrement is defined as "deterioration in the ability to remain vigilant for critical signals with time, as indicated by a decline in the rate of the correct detection of signals". Vigilance decrement is most commonly associated with monitoring to detect a weak target signal. Detection performance loss is less likely to occur in cases where the target signal exhibits a high saliency. For example, a radar operator would be unlikely to miss a rare target at the end of a watch if it were a large bright flashing signal, but might miss a small dim signal.



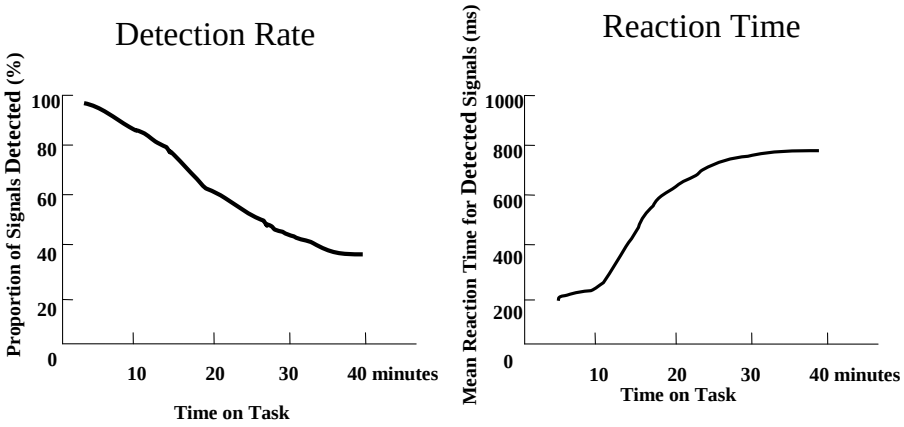

Under most conditions, vigilance decrement becomes significant within the first 15 minutes of attention, but a decline in detection performance can occur more quickly if the task demand conditions are high. This occurs in both experienced and novice task performers. Vigilance had traditionally been associated with low cognitive demand and vigilance decrement with a decline in arousal pursuant to the low cognitive demand, but these views are no longer widely held.

More recent studies indicate that vigilance is hard work, requiring the allocation of significant cognitive resources, and inducing significant levels of stress.

# Types of Vigilance Tasks

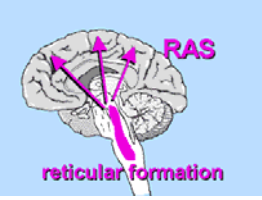
- Low vs. High Event Rate
  - Number of non-signal events per unit time
- Simultaneous vs. Successive
  - Memory load imposed in successive tasks
- Sensory vs. Cognitive
  - Signal defined on physical vs. symbolic or semantic level

# Typical Vigilance Results



# Arousal Theory

- Decline in detection rate over time (vigilance decrement) is due to a decrease in physiological arousal due to the repetitive nature of the task
- Ascending Reticular Activating System — Brain stem activates diverse regions of cortex
- Boring tasks stimulate less






One of the first theories that sought to explain performance decrement was the arousal theory which was derived from arousal theories on general human performance. The main assumption of this theory is that the performance decrement is due to lack of stimulation, which is needed to maintain alertness at a required level. More specifically, it is assumed that a state of vigilance cannot be maintained under conditions of repetitive stimulation, due to perceptual habituation. Hence, the arousal theory predicts that vigilance performance deteriorates most steeply in tasks that are boring and monotonous. The calssic vigilance task is indeed monotonous and undemanding (the clock).

# Arousal Theory: Pros

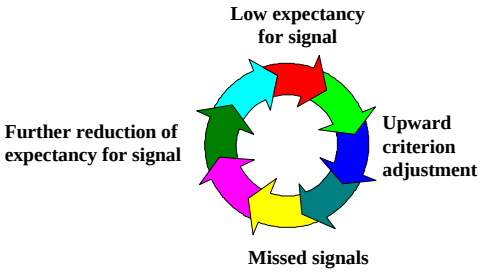
- Behavioral activity measures, physiological (EEG, skin conductance, etc.), and subjective report measures all point to decreased arousal with time on task
- *Overall* level of vigilance is significantly affected by factors that influence arousal
  - ⇑: Caffeine, other stimulant drugs; morning vs. late night performance; varied auditory stimulation, etc.
  - ⇓: Alcohol, other depressant drugs; sleep deprivation; loud noise.

# Arousal Theory: Cons

- Decline in arousal *correlates* with vigilance decrement, but causal relation difficult to show
- Many factors that change arousal level do not affect the vigilance decrement over time.

# Expectancy Theory: Pros

- **Subjects perceive and expect signals to occur at a very low rate. As a result, they become more "conservative" in responding and adjust their criterion upwards**
- **Leads to a greater likelihood of missing a signal**
- **This further reduces expectancy for a signal, and so on in a "vicious cycle"**
- **Support for theory in Reaction Time**
- **Support for theory when signal probability is lowered, detection rate decreases and vigilance decrement increases**





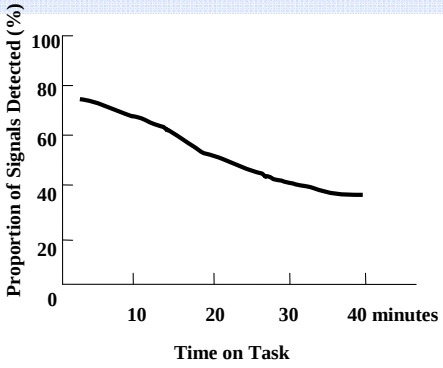

Detection and identification of a stimulus are faster when there is no temporal or spatial uncertainty about its appearance. Temporal and/or spatial uncertainty is likely to reduce vigilance performance. This is the essential prediction of *expectancy theory*. Optimal preparedness of the observer requires temporal and spatial certainty; obviously vigilance tasks are less than optimal in this respect. Although the major focus of expectancy theory is on the overall low performance, it can also serve to account for parts of the vigilance decrement. With infrequent signals at random intervals, high levels of preparedness might initially exist at times when no signal is presented; in addition, signals will be presented at low levels of preparedness. This discourages occasional high levels of preparedness in general so that whatever benefits accrue from them will vanish in the course of a watch.

# Expectancy Theory: Cons

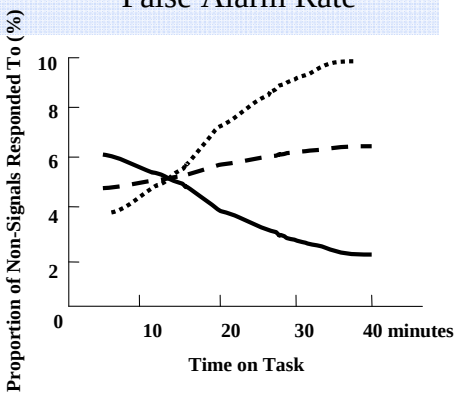
- Vigilance decrement occurs even when subjects are specifically trained to match their "expectancy" to the actual signal rate
- No independent measure of the construct of "expectancy"
- The theory cannot account for *sensitivity* decrement over time in vigilance

# False Alarm Rates in Vigilance Tasks

Detection Rate



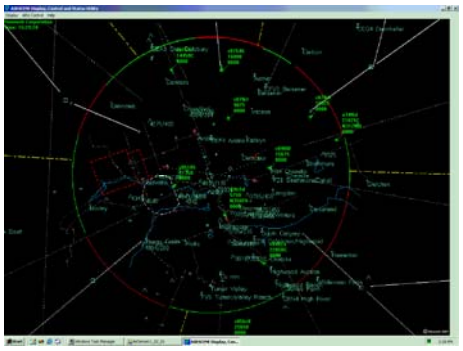

False Alarm Rate



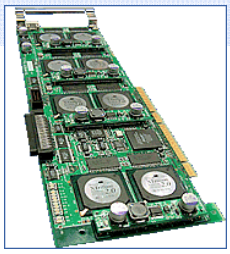

- Early vigilance studies did not report FA rates
- If they did, they treated them as “guesses” or computed biased measures of accuracy

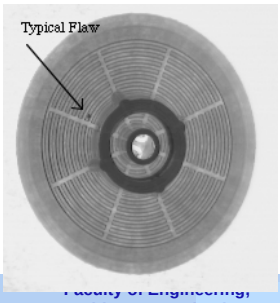
# Air Traffic Control

**Signal: Two aircraft in "conflict" (within 1 mile vertically or 5,000 ft horizontally)**



# Inspection and Quality Control





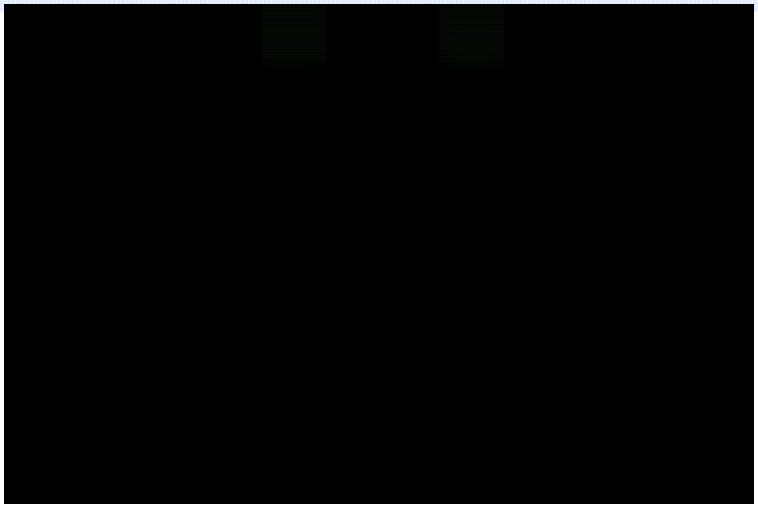

**Signal: Manufactured product with specified flaw**

# Reducing Loss of Vigilance

- Show signal examples (reduce memory load)
- Increase signal salience (reduce perceptual load)
  - Blinking
  - Adding coherent motion
  - Alternate sensory modalities
- Lower event rate (if possible)
- Insert false signals (TSA program for baggage screeners)
- Allow reporting with multiple levels of confidence

# Another “Spot the Differences” Video

# Thwarting Vigilance



# Video Vigilance

- Challenge:
  - A 1m x 1m space will be taped off in the lab
  - An activity will take place in the space over a 24 hour period
  - Determine what that activity was
- Helpful hints
  - Detecting motion is quite helpful
  - Recording at the right time is necessary
  - More than one point of view is always helpful
- When will it take place?
  - Some time between noon on the 26th and noon on the 27th of October
  - Bring your answers to class with discussion to take place at that time.