King Saud University

College of Engineering

IE - 341: "Human Factors"

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Chapter 3. Information Input and Processing Part – I*



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Chapter Overview

- Information:
 - How it can be measured (part I)
 - How it can be displayed (part II)
 - How it can be coded (part II)



Information Theory

- Information Processing is AKA:
 - Cognitive Psychology
 - Cognitive Engineering
 - Engineering Psychology
- Objectives of Information Theory:
 - Finding an operational definition of information
 - Finding a method for measuring information
 - Note, most concepts of Info. Theory are descriptive (i.e. qualitative vs. quantitative)
- Information (Defⁿ):
 - "Reduction of Uncertainty"
 - Emphasis is on "highly unlikely" events

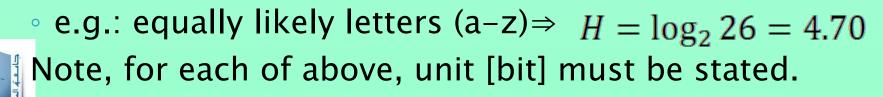


- Example (information in car):
 - "Fasten seat belt": likely event \Rightarrow not imp. in Info. Th.
 - "Temperature warning": unlikely event \Rightarrow imp.

Unit of Measure of Information ► Case 1: ≥ 1 equally likely alternative events:

$$H = \log_2 N = \frac{\log N}{\log 2}$$

- *H* : amount of information [Bits]
- N: number of equally likely alternatives
- e.g.: 2 equally likely alternatives $\Rightarrow H = \log_2 2 = 1$ \Rightarrow **Bit** (Defⁿ): "amount of info. to decide between **two** equally likely (i.e. 50%–50%) alternatives"
- e.g.: 4 equally likely alternatives $\Rightarrow H = \log_2 4 = 2$
- e.g.: equally likely digits $(0-9) \Rightarrow H = \log_2 10 = 3.32$



Cont. Unit of Measure of Information • Case 2: \geq 1 non-equally likely alternatives: $h_i = \log_2 \frac{1}{p_i}$

- h_i : amount of information [Bits] for single event, i
- $\cdot p_i$: probability of occurrence of single event, i
- Note, this is not usually significant
 - (i.e. for individual event basis)



Cont. Unit of Measure of Information Case 3: Average info. of non-equally likely series of events: N

$$H_{av} = \sum_{i=1}^{n} p_i \left(\log_2 \frac{1}{p_i} \right)$$

 $_{\circ}H_{av}$: average information [Bits] from all events

- p_i : probability of occurrence of single event, i
- N: num. of non-equally likely alternatives/events
- e.g.: 2 alternatives (N = 2)
 - Enemy attacks by land, $p_1 = 0.9$
 - Enemy attacks by sea, $p_2 = 0.1$

$$\stackrel{\Rightarrow}{\to} H_{av} = \sum_{i=1}^{2} p_i \left(\log_2 \frac{1}{p_i} \right) = p_1 \left(\log_2 \frac{1}{p_1} \right) + p_2 \left(\log_2 \frac{1}{p_2} \right)$$
$$= 0.9 \left(\log_2 \frac{1}{0.9} \right) + 0.1 \left(\log_2 \frac{1}{0.1} \right) = 0.47$$



Cont. Unit of Measure of Information Case 4: Redundancy:

- If 2 occurrences: equally likely \Rightarrow
 - p₁ = p₂ = 0.5 (i.e. 50 % each)
 - \Rightarrow $H = H_{\text{max}} = 1$
- In e.g. in last slide, departure from max. info.

$$= 1 - 0.47 = 0.53 = 53\%$$

% *Redundancy* =
$$\left(1 - \frac{H_{av}}{H_{max}}\right) * 100$$

- Note, as departure from equal prob. $\uparrow \Rightarrow \%$ Red. \uparrow
- e.g.: not all English letters equally likely: "th", "qu"
 - \Rightarrow %Red. of English language = 68 %
 - PS. How about Arabic language?



Choice Reaction Time Experiments Experiments:

- Subjects: exposed to different stimuli
- Response time is measured
- e.g. 4 lights 4 buttons
- *Hick* (1952):
 - Varied number of stimuli (eq. likely alternatives)
 - He found:
 - As # of eq. likely alt. $\uparrow \Rightarrow$ reaction time to stimulus \uparrow
 - Reaction time vs. Stimulus (in Bits): linear function
- *Hyman* (1953):
 - Kept number of stimuli (alternatives) fixed
 - Varied prob. of occurrence of events \Rightarrow info. Varies



- He found: **"Hick-Hyman Law"**
 - AGAIN: Reaction time vs. Stimulus (in Bits): linear function!