A Decision Model for Psychophysics

Reading: Macmillan & Creelman, Chaps. 1 & 2

Three Things to Learn

- **Procedure**
  - **What are the stimuli?**
  - **How do you present them?**
  - **What are the responses?**
  - **How do you organize the data?**
- **Model**
  - **What are the assumptions?**
  - **What is the model based on these assumptions?**
- **Data Processing**
  - **How do you process the data?**
  - **What are the results (e.g., threshold)?**

Introduction to Signal Detection Theory (SDT)

- **Tanner & Swets, 1954**
- **Key Properties of SDT**
  - **Noise in perception**
  - **Probabilistic / stochastic approach**
  - **Decision process (*a priori* info, bias)**
  - **Experimental procedure**
  - **Popular in literature**

Why Do We Care About SDT?

- It provides a means to separate decision processes (e.g., bias) from perception.
- We will develop a decision model for psychophysics

The Procedure for One-Interval (1-I) Experiments

- **Name:**
  - **One-Interval, Two-Alternatives (1I 2A)**
  - **Also known as the "yes-no" experiment (see Macmillan&Creelman's book)**
- **There are two stimuli S_i (i=1, 2); e.g.,**
  - **S_1="softer tone", S_2="louder tone"**
  - **S_1="softer spring", S_2="harder spring"**
  - **S_1="new face", S_2="old face" (M&C)**
  - **S_1="noise", S_2="signal embedded in noise"**

(*cont.*)

- **On each trial, S_i is presented with an *a priori* probability of $P(S_i)$, where $P(S_1)+P(S_2)=1$**
- **There are two admissible responses R_j (j=1, 2); e.g.,**
  - **R_1="softer tone", R_2="louder tone"**
  - **R_1="1", R_2="2"**
  - **R_1="no", R_2="yes" (hence "yes-no" exp.)**
- **For simplicity, we assume that R_1 is the correct response to S_1, and R_2 is the correct response to S_2**
- **Trial-by-trial correct-answer feedback is optional**

Data from a 1-I Experiment

	R_1	R_2
S_1	n_{11} *Correct Rejections*	n_{12} *False alarms*
S_2	n_{21} *Misses*	n_{22} *Hits*

- **f(R_1|S_1)=$n_{11}/(n_{11}+n_{12})$: frequency of responding R_1 given S_1. We use frequency to estimate probability.**
- **P(R_1|S_1): probability of responding R_1 given S_1**
- **p(R_1|S_1): probability density function**
- **There are only two *independent* measures: *F* and *H*.**

Three Examples

(1)

	R_1	R_2
S_1	48	2
S_2	1	49

(2)

	R_1	R_2
S_1	5	45
S_2	1	49

(3)

	R_1	R_2
S_1	2	48
S_2	49	1

In-Class Demo: 1-I Experiment

- **Go to “Online Expeirments”**
- **Go down to “Part II. Decision Model for Psychophysics”**
- **Go to “One-interval Experiment”**
- **Select “1. Curvature detection”**

Discussion of In-Class Demo

- Summarize the procedure
  - What are the stimuli?
  - How do you present them?
  - What are the responses?
  - How do you organize the data?
- Sample output

	R1	R2
S1	37	13
S2	14	36

H = 0.72

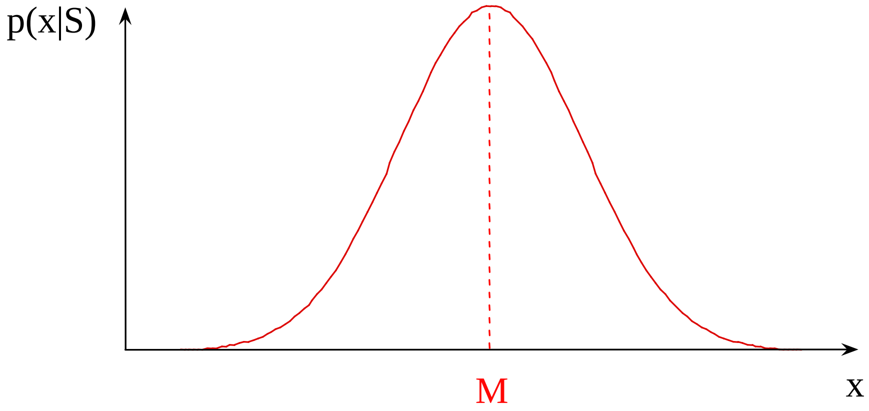
F = 0.26

d' = 1.22

c = 0.03

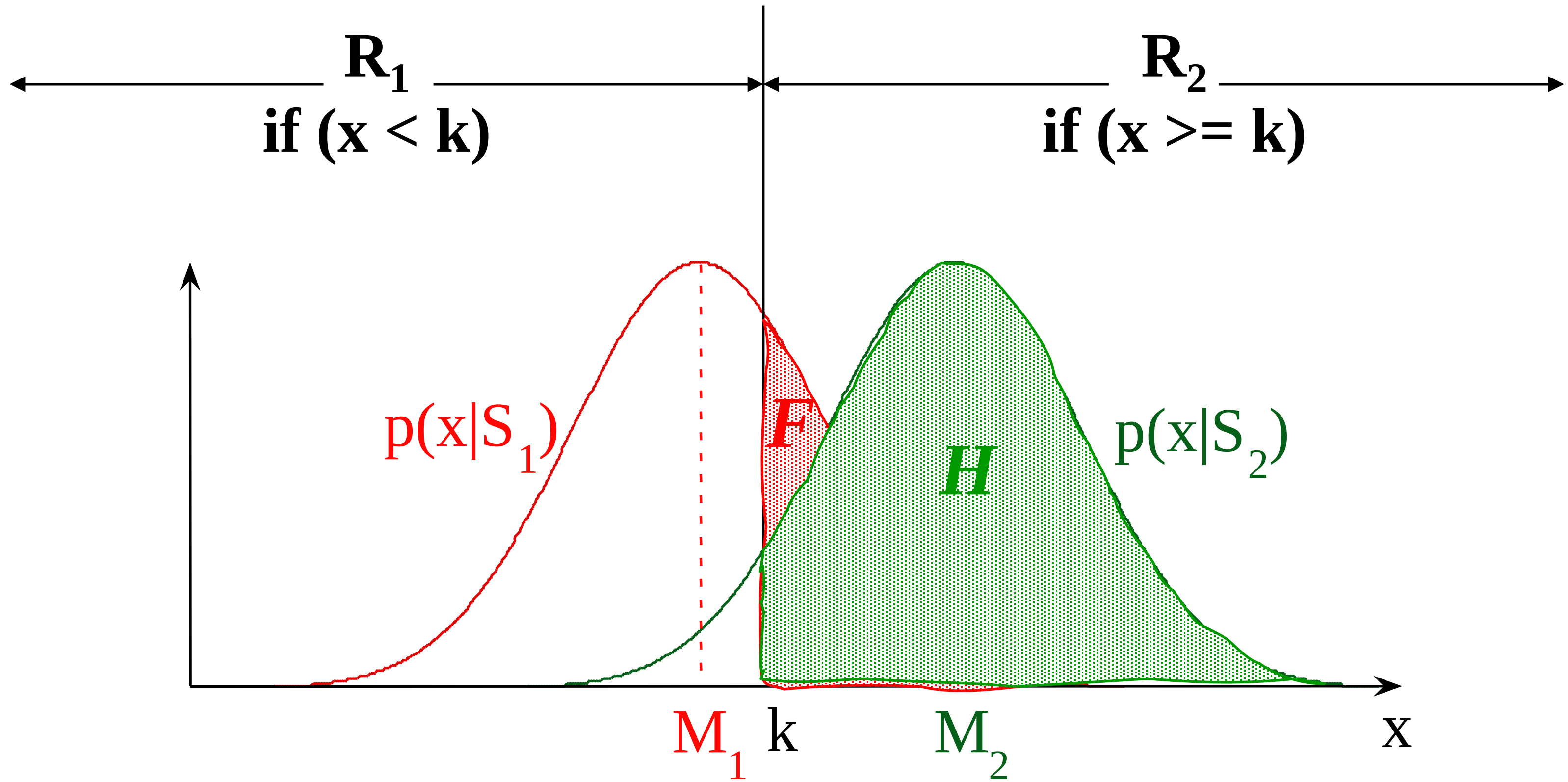
- Email your results to “hongtan@purdue.edu”

Decision Model for 1-I Exp.



- A (Perceptual) Decision Space
  - x: random variable ("decision axis")
  - Each stimulus presentation determines a value of x
  - p(x|S): conditional probability density function
  - M: mean/expected value

$$M = \int_{-\infty}^{+\infty} x \, p(x \mid S) \, dx$$



$$F = \mathrm{P}(R_2 \mid S_1) = \int_k^{\infty} p(x \mid S_1)\, dx$$

$$H = \mathrm{P}(R_2 \mid S_2) = \int_k^{\infty} p(x \mid S_2)\, dx$$