Cognitive Illusions

• The Conjunction Fallacy

Linda is a women's studies major with a part-time job. She feels passionately about women's rights in the workplace and hopes to go to law school someday. Which is more probable?

a) Linda is a bank teller

b) Linda is a bank teller and active in the feminist movement

Think of 200 women like Linda. How many of them are:

a) bank tellers?

b) bank tellers and active in the feminist movement?

Cognitive Illusions

• Overconfidence Bias

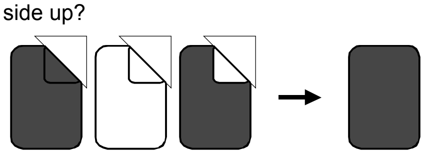
An overconfidence bias is seen when people are asked to estimate the probability that they answered a single question correctly. This bias is reduced when they are asked to estimate the number of correct answers in a list of 50 questions.

Criticism: It is unreasonable to ask people to use probabilities to reason about single events. Also, the use of a confidence estimate is different than a probability estimate. (I could be 0% confident of my answer and have a 50% probability of answering correctly.) It is unclear which was used.

Individuation in Statistical Inference

Three cards are in a hat. One is red on both sides. One is white on both sides. One is red on one side and white on the other. A single card is drawn randomly and tossed into the air.

What is the probability that the red-red card was drawn, assuming that the drawn card lands with a red side up?



(Bar-Hillel & Falk, 1982)

Individuation in Statistical Inference

The majority of people (66-79%) answer incorrectly.

Fewer than 10% give the correct answer.

The frequency of the wrong answer points to two problems with the question:

1. It was posed in a probabilistic, not frequency, format.

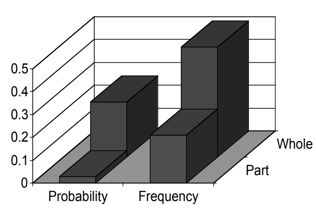
2. It parses whole objects into parts (sides of a card), which is not a natural format for making inferences.

Individuation in Statistical Inference

If you present the same problem, but add that the drawing is repeated 30 times, the percent of correct responses rises to 28% (Brase, Cosmides & Tooby, 1997).

On another set of problems (candy canes) the following results were found:

Both framing the problem in terms of frequency and whole objects increased the proportion of correct answers.



Probability Format

The probability that a patient has breast cancer is 1%. ← Prior probability

If a patient has breast cancer, the probability that a radiologist will correctly diagnose it is 79%. ← Sensitivity or hit rate

If a patient has a benign lesion, the probability that the radiologist will incorrectly diagnose it as cancer is 9.6% ← False positive rate

What is the probability that a patient with a positive mammography actually has breast cancer?

Frequency Format

A physician has seen 1000 people, 10 of whom have a certain disease.	← Prior probability
Of those 10, 8 showed symptoms.	← Sensitivity or hit rate
Of the 990 not afflicted, 95 showed symptoms.	← False positive rate

What is the probability that a new patient with symptoms has the disease?

About 50% of physicians get the right answer.

Bayes' Theorem

$$p(D|S) = \frac{p(D) * p(S|D)}{p(D) * p(S|D) + p(D') * p(S|D')}$$

p(D|S) = probability of a disease given a symptom

p(D) = probability of the disease in the overall population

p(S|D) = probability of the symptom in people with the disease

p(D') = probability that someone doesn't have the disease

p(S|D') = probability of having the symptom with no disease

Gigerenzer's Method

$$P(D|S) = \frac{\text{Number with both the symptom and disease}}{\text{Total number with the symptom}}$$

$$p(D|S) = \frac{p(D) * p(S|D)}{p(D) * p(S|D) + p(D') * p(S|D')}$$

p(D) * p(S|D) = number with both the symptom and disease

p(D') * p(S|D') = number with the symptom but no disease

p(D) * p(S|D) + p(D') * p(S|D') = total number with the symptom

Gigerenzer's argument has two parts:

1. Evolutionary (and developmental) primacy of frequency formats

"If there are mental algorithms that perform Bayesian-type inferences from data to hypotheses, these are designed for event frequencies by natural sampling"

2. Ease of computation

Arguments for Adaptation

"mental algorithms were designed for frequency formats"

1. Humans can monitor frequencies with fair accuracy.
2. Humans process frequencies almost automatically.
3. Evidence from counting in animals and children.
4. Probability learning derives from frequency learning.

Humans can monitor frequencies with fair accuracy.

- People remember (relative) frequencies well (e.g. people are very accurate when asked about the relative number of restaurants in fast-food chains).
- We probably don't code frequencies by overt counting. Subjects given explicit counting directions, a pencil and paper perform the same as those without on relative frequency tasks.

Coding Frequencies

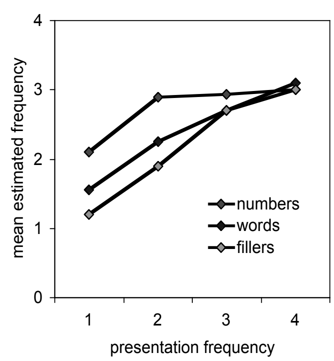
- There is evidence for both indirect and direct coding.
- Indirect theories of frequency calculation posit that frequencies are derived from aspects of memory other than frequency (like the strength of connections in a neural network).
- Direct theories say frequencies are represented by a special frequency-counting mechanism (compatible with Gigerenzer).

Evidence for Direct Coding

Jonides & Jones (1992) gave the following list of words in different frequencies and asked subjects to either write down the first word or the first number associated with the word. The numbers condition interfered with the subjects' recall of word frequencies more than did the words condition.

1	2	3	4
Lone	Twins	Triplicate	Quadrangle
Solo	Couple	Few	Wheels
Alone	Pair	Triplets	Quartet

Estimated vs. Actual Relative Frequency



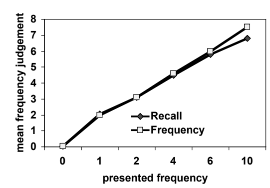
The processing of the words in the numbers condition interfered equally with frequency processing for all words. It did not increase with magnitude of the number associated with the word. Further experiments show that this interference is generated at encoding, not retrieval.

Humans process frequencies almost automatically.

Hasher & Zacks (1984) show that frequency processing is automatic by giving evidence for the following criteria:

1. People process frequencies equally well whether they are consciously intending to or not.

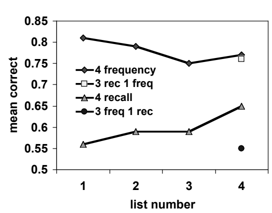
People were told that they would be given either a recall test or a frequency test before presentation of a word list. These instructions made no difference in performance.



Humans process frequencies almost automatically.

Hasher & Zacks (1984) show that frequency processing is automatic by giving evidence for the following criteria:

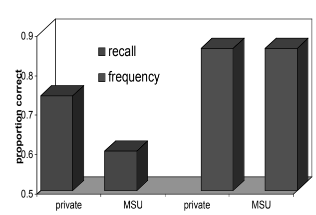
2. Training does not improve performance on frequency tests.



Humans process frequencies almost automatically.

Hasher & Zacks (1984) show that frequency processing is automatic by giving evidence for the following criteria:

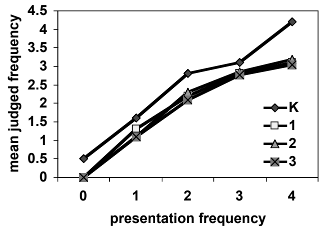
3. Education, social class and "intelligence" have little impact on frequency estimating ability.



Humans process frequencies almost automatically.

Hasher & Zacks (1984) show that frequency processing is automatic by giving evidence for the following criteria:

4. Frequency processing is unaffected by age after about five years.



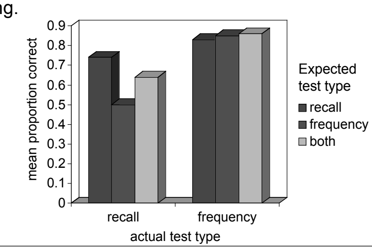
Humans process frequencies almost automatically.

Hasher & Zacks (1984) show that frequency processing is automatic by giving evidence for the following criteria:

5. Simultaneous processing demands have no effect on frequency processing.

Subjects were told that they would be tested on recall, frequency, or both before presentation of a word list.

Expected test type influenced recall performance, but not frequency.

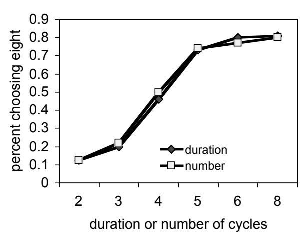


Evidence from Counting in Animals

Numerosity vs. length of signal (Meck & Church 1983)

Rats were trained to press one lever in response to a sequence of 2 tones in 2 seconds and another lever in response to 8 tones in 8 seconds.

After training, rats were given either 4 tones lasting 2-8 second or 2-8 tones lasting 4 seconds.



Critiques of an Evolved Module for Frequencies

- Low Accuracy Even with Frequencies

If we have a module designed to reason with frequencies, why do even physicians (supposedly highly intelligent people) only get about half the frequency formatted problems correct?

- Ease of Computation

Why would we need to posit an evolved mechanism if increased ease of computation due to a frequency format is sufficient to explain improved performance? Is it sufficient?