Name ________________________

Statistics Laboratory — *z*-Scores and Signal Detection Theory

Introduction to Signal Detection Theory

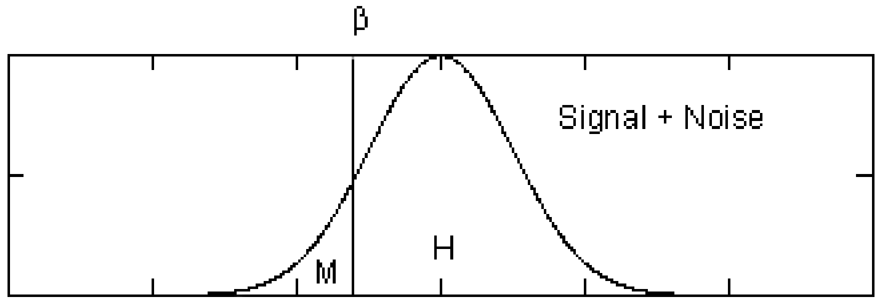
First of all, you need to know something about the problem. Think about a perception experiment in which a participant is asked to determine whether or not a very indistinct stimulus has been presented on a given trial. The participant responds either "Yes" or "No." And, of course, the stimulus could either have been present on the trial or not. This characterization of a signal detection experiment should strike you as quite similar to our discussion of hypothesis testing. That is, the participant responds "Yes," but the stimulus could be present (Hit) or absent (False Positive or False Alarm). You should recognize the False Alarm as equivalent to a Type I error (saying that there's a difference when there isn't). Should the participant respond "No," the stimulus could have been present (Miss) or absent (Correct Rejection). The Miss is equivalent to a Type II error (saying that there's no difference when there really is one). Thus, the tabular representation would look like this:

	Stimulus is Present	**Stimulus is not Present**
Participant says, "Yes, it's there."	Hit	False Alarm
Participant says, "No, it's not there."	Miss	Correct Rejection

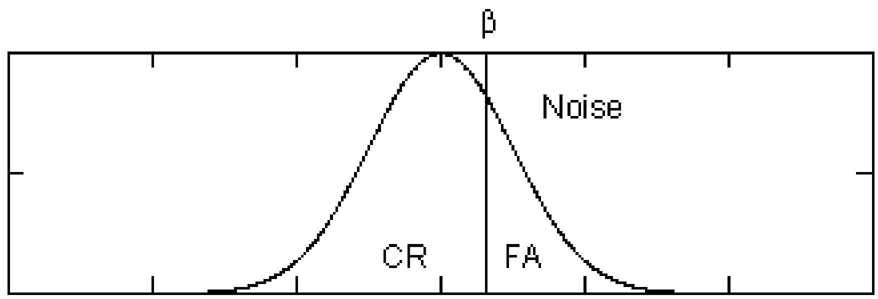
Computing Criterion (β) and Sensitivity (d')

Now, let's put some numbers into this experiment. Suppose that there are 100 trials, with 50 trials on which the stimulus is present (called a Signal + Noise trial, because the signal is presented on top of any background noise that might be present) and 50 trials on which the stimulus is not present (called a Noise trial, because the only thing present is background noise). If, on the 50 Signal + Noise trials the participant said "Yes" on 40 trials and "No" on 10 trials, then that participant got 80% Hits and 20% Misses. Note that the Hits and Misses are complementary, so if we know the Hit %, we also know the Miss %. Similarly, if on the 50 Noise trials, the participant said "Yes" to 20 trials and "No" to 30 trials, then that participant got 40% False Alarms and 60% Correct Rejections. Once again, the percentages are complementary, so the information is redundant.

Given the redundancy of information, we really use only the Hit % and the False Alarm % to construct our measures. First of all, let's consider the distribution of Signal + Noise trials as normally distributed. The Hit % actually determines where the participant's criterion (β) must have been. That is, in order to produce 80% Hits, the criterion must have been a line that puts 80% of the distribution above it and 20% of the distribution below it. Thus, eyeballing the distribution, I would place the criterion as seen below:

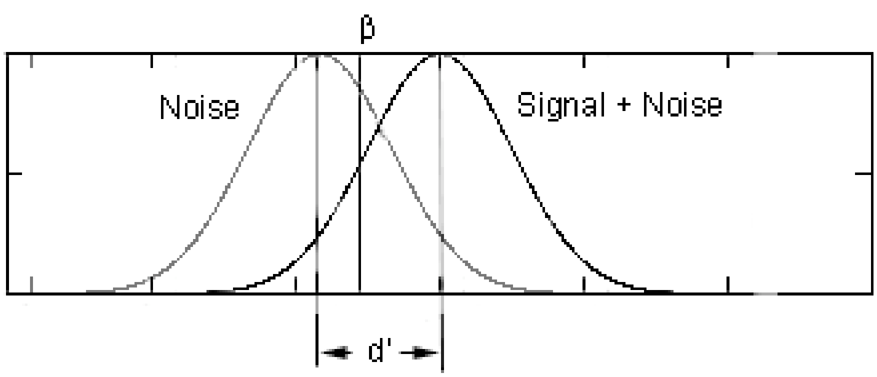


For the Noise distribution, given the proportions observed, the criterion must have been placed as seen below:



OK, given that we're dealing with normal distributions, you should be able to determine the z-scores that would be associated with the percentages/proportions seen in the two curves above. Look them up now.

Now here's the magic. Those criteria must actually be the same, because the participant is simply making decisions about each trial throughout the experiment. Thus, we can line them up. In so doing, we can determine the sensitivity of the participant (*d'*) by computing the number of standard deviation (*z*-score) units separate the means (peaks) of the two distributions. So, for this case, compute the *d'*.



% Hits	z-score Hits	% False Alarms	z-score FAs	d' (|z| + |z|)
80		40		
50		50		
90		10		
80		10		

Does this process make sense to you? If so, then you have a good head start toward understanding how psychological researchers use one particular measure (the *z*-score) in a practical fashion to understand decision processes.

Applying Signal Detection Theory to Memory Research

How could you assess a person's memory? Research on memory has a long history in psychology. The very earliest researcher (Ebbinghaus) conducted systematic memory research on himself. We've come a long way since Ebbinghaus and the Method of Savings.

One way to assess memory is through the recall paradigm. Another way to assess memory is through the recognition paradigm. You might want to think about which paradigm you would use to investigate a person's memory. For our purposes, we're going to focus on the recognition paradigm.

In the recognition paradigm, a participant first goes through the acquisition phase. During this phase, the participant is given a series of items (words, pictures, etc.). If the participant expects a memory test, the learning is called intentional. If the participant is given some cover task that leads him or her to expect no test of memory, then the learning task is called incidental. After the acquisition phase, the participants may go through a distraction phase, in which they are given a task to take their minds off the items in the acquisition phase. Can you think about why the distraction phase may be important? Finally, the participant is given a test. In the test phase of the study, the participant will be given a list of items that includes those items seen during acquisition. A number of new items will be interspersed in the list. Thus, the participant must make a decision as to whether or not each item at test is an item from the acquisition list (Yes) or is a new item (No).

At this point, you should note the similarity between the recognition paradigm and the signal detection paradigm. Thus, on a test, half the items might be old. The participant could call an old item old (Hit) or say that it's new (Miss). Alternatively, the participant could call a new item new (Correct Rejection) or say that it's old (False Alarm). Moreover, it may also be clear to you how important the use of d' might be in assessing a person's memory. Can you see how *d'* would be useful to counteract a particular guessing strategy?

For your own data, compute the appropriate values below:

Percent Hits	*z*-Score for Hits	Percent False Alarms	*z*-Score for False Alarms	*d'*

Recognition Test

1	Pearl	Old	New	51	Pilot	Old	New
2	Vote	Old	New	52	Sleep	Old	New
3	Square	Old	New	53	Indian	Old	New
4	Train	Old	New	54	Suffix	Old	New
5	Short	Old	New	55	Jacket	Old	New
6	Student	Old	New	56	Wife	Old	New
7	Food	Old	New	57	Ticket	Old	New
8	Circus	Old	New	58	Cut	Old	New
9	Pepper	Old	New	59	Harem	Old	New
10	Letters	Old	New	60	Mountain	Old	New
11	Priest	Old	New	61	Trees	Old	New
12	Gullet	Old	New	62	Church	Old	New
13	Knowledge	Old	New	63	Bell	Old	New
14	Lamb	Old	New	64	Pestle	Old	New
15	Butterfly	Old	New	65	Fear	Old	New
16	Bitter	Old	New	66	Lobby	Old	New
17	Temple	Old	New	67	Eagle	Old	New
18	Eye	Old	New	68	Leaves	Old	New
19	Lettuce	Old	New	69	Oven	Old	New
20	Author	Old	New	70	Car	Old	New
21	Cookie	Old	New	71	Star	Old	New
22	Soap	Old	New	72	Loud	Old	New
23	Platform	Old	New	73	Bridge	Old	New
24	Mutton	Old	New	74	Queen	Old	New
25	Water	Old	New	75	Discord	Old	New
26	Chair	Old	New	76	Farm	Old	New
27	Movie	Old	New	77	Hold	Old	New
28	Wafer	Old	New	78	Loft	Old	New
29	Sign	Old	New	79	Candy	Old	New
30	Justice	Old	New	80	Feather	Old	New
31	Meeting	Old	New	81	Birthday	Old	New
32	Oboe	Old	New	82	Earth	Old	New
33	Valley	Old	New	83	Broader	Old	New
34	Pressure	Old	New	84	Mermaid	Old	New
35	Case	Old	New	85	Bat	Old	New
36	Problem	Old	New	86	Buffoon	Old	New
37	Note	Old	New	87	Pencil	Old	New
38	Phone	Old	New	88	Light	Old	New
39	Question	Old	New	89	Smoke	Old	New
40	Building	Old	New	90	Beautiful	Old	New
41	Dogma	Old	New	91	Mind	Old	New
42	Nail	Old	New	92	Joy	Old	New
43	Hand	Old	New	93	Cow	Old	New
44	Preview	Old	New	94	City	Old	New
45	Reason	Old	New	95	Donkey	Old	New
46	Night	Old	New	96	Magnate	Old	New
47	Girl	Old	New	97	Date	Old	New
48	Write	Old	New	98	Music	Old	New
49	Anger	Old	New	99	Beard	Old	New
50	Numbers	Old	New	100	Soft	Old	New