Type I and Type II Errors - Making Mistakes in the Justice System

Ever wonder how someone in America can be arrested if they really are presumed innocent, why a defendant is foun instead of innocent, or why Americans put up with a justice system which sometimes allows criminals to go free on These questions can be understood by understanding the similarity of the American justice system to hypothesis test statistics and the two types of errors it can produce. (This discussion assumes that the reader has at least been introd normal distribution and its use in hypothesis testing. Also please note that the American justice system is used for cc Others are similar in nature such as the British system which inspired the American system)

True, the trial process does not use numerical values as does hypothesis testing in statistics, but both the justice syste statistical versions of hypothesis testing share at least three common elements (other than a lot of jargon that sounds talk):

1. **The alternative hypothesis -** This is the reason a criminal is arrested. Obviously the police don't think the a is innocent or they wouldn't arrest him. In statistics the alternative hypothesis is the hypothesis the researche evaluate.
2. **The null hypothesis -** In the criminal justice system this is the presumption of innocence. In both the judicia statistics the null hypothesis indicates that the suspect or treatment didn't do anything. The null is the logical the the alternative. For example "not white" is the logical opposite of white. Colors such as red, blue and gre black all qualify as "not white".
3. **A standard of judgment -** In the justice system and statistics there is no possibility of absolute proof and so has to be set for rejecting the null hypothesis. In the justice system the standard is "a reasonable doubt". The hypothesis has to be rejected beyond a reasonable doubt. In statistics the standard is the maximum acceptabl that the effect is due to random variability in the data rather than the cause being investigated. This standard 5% which is called the alpha level.

It only takes one good piece of evidence to send a hypothesis down in flames but an endless amount to prove it. If th rejected then logically the alternative hypothesis is accepted. This is why both the justice system and statistics conce disproving or rejecting the null hypothesis rather than proving the alternative. It's much easier to do. If a jury rejects presumption of innocence, the defendant is pronounced guilty.

Unfortunately, neither the legal system or statistical testing are perfect. A jury sometimes makes an error and an inn goes to jail. Statisticians, being highly imaginative, call this a type I error. Civilians call it a travesty.

In the justice system, failure to reject the presumption of innocence gives the defendant a not guilty verdict. This me the standard for rejecting innocence was not met. It does not mean the person really is innocent. It would take an en of evidence to actually prove the null hypothesis of innocence.

Sometimes, guilty people are set free. Statisticians have given this error the highly imaginative name, type II error.

Americans find type II errors disturbing but not as horrifying as type I errors. A type I error means that not only has person been sent to jail but the truly guilty person has also gone free. In a sense, a type I error is twice as bad as a ty Needless to say, the American justice system puts a lot of emphasis on avoiding type I errors. This emphasis on avo errors, however, is not true in all cases where hypothesis testing is done.

Justice System - Trial		Statistics - Hypothesis Tes	
Defendant	Defendant	Null Hypoth	Null Hyp

	Innocent	Guilty		True	Fals
Reject Presumption of Innocence (Guilty Verdict)	Type I Error	Correct	Reject Null Hypothesis	Type I Error	Corre
Fail to Reject Presumption of Innocence (Not Guilty Verdict)	Correct	Type II Error	Fail to Reject Null Hypothesis	Correct	Type II

It would be nice to completely eliminate both error types but it can't be done. In fact, reducing one causes the other to become higher. This happens because the appearance of guilt and innocence are not clear cut. Innocent people can appear to be guilty and guilty people appear to be innocent.

The normal distribution as shown in figure 1 can be used to represent the variability in the appearance of guilt for the population of innocent suspects. In a homicide investigation, for example, just about anyone who is a friend, relative, associate, or was in the immediate vicinity of the crime will initially be considered a suspect.

People represented by the left hand tail would be either criminals in jail who couldn't have committed the crime or super upstanding citizens who would virtually never be accused in the first place. Those represented by the right tail would be the "usual suspects", innocent people who appear to be guilty such as hot heads, career criminals, or bad dressers.

If the standard of judgment were positioned as shown in figure 2 then all the innocent people represented by the red area would be judged guilty if they were unlucky enough to be arrested and tried for the crime (type I errors). Since the normal distribution extends to infinity, type I errors would never be zero even if the standard of judgment were moved to the far right. The only way to prevent all type I errors would be to arrest no one. Unfortunately this would drive the number of unpunished criminals or type II errors through the roof.

Figure 3 shows what happens not only to innocent suspects but also guilty ones when they are arrested and tried for crimes. In this case, the criminals are clearly guilty and face certain punishment if arrested.

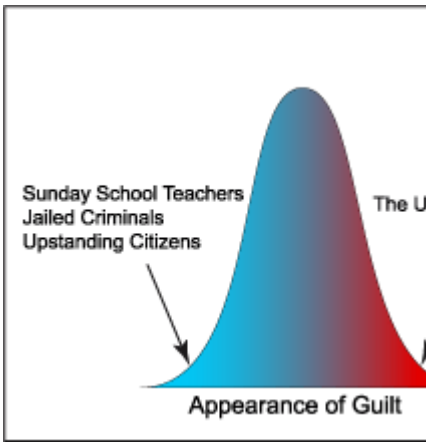


figure 1. Possible Suspects Who Are In

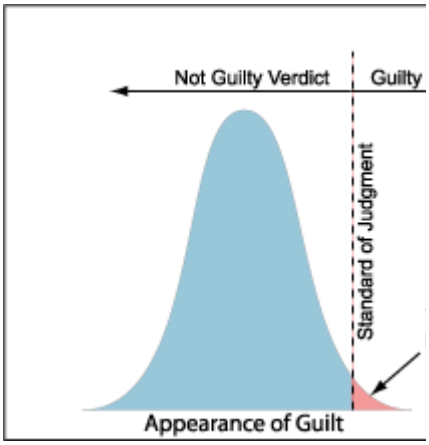


figure 2. Innocent Suspects Who Are A Tried for a Crime

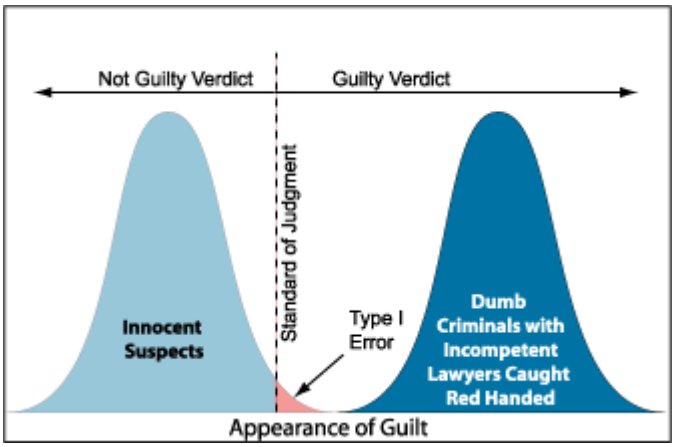


figure 3. What Happens to Innocent Suspects or Clearly Guilty Criminals if They Are Arrested and Tried

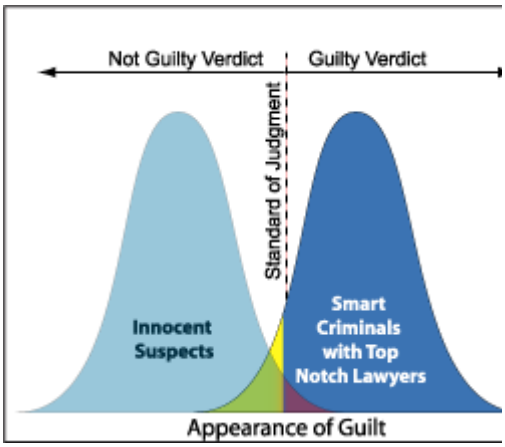


figure 4. What Happens to Innocent Suspects c Not So Clearly Guilty Criminals if They Are Arrested and Tried.

If the police bungle the investigation and arrest an innocent suspect, there is still a chance that the innocent person could go to jail. Also, since the normal distribution extends to infinity in both positive and negative directions there is a very slight chance that a guilty person could be found on the left had side of the standard of judgment. This means he would incorrectly be set free.

Unfortunately, justice is often not as straightforward as illustrated in figure 3. Figure 4 shows the more typical case in which the real criminals are not so clearly guilty. Notice that the means of the two distributions are much closer together. As before, if bungling police officers arrest an innocent suspect there's a small chance that the wrong person will be convicted. However, there is now also a significant chance that a guilty person will be set free. This is represented by the yellow/green area under the curve on the left and is a type II error.

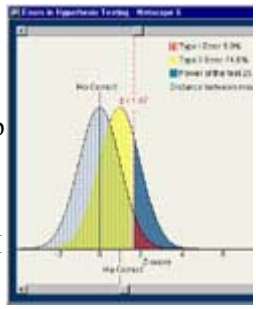
If the standard of judgment is moved to the left by making it less strict the number of type II errors or criminals going free will be reduced. This could be done by throwing out the reasonable doubt standard and instructing the jury to find the defendant guilty if they think it's possible that she did the crime. However, this would make the type I errors unacceptably high. While fixing the justice system by moving the standard of judgment has great appeal in the end there is no free lunch.

Statistical Errors Applet

The applet below can alter both the standard of judgment and distance between means for a statistical hypothesis test. It calculates type I and type II errors when you move the sliders. Like any analysis of this type it assumes that the distribution for the null hypothesis is the same shape as the distribution of the alternative hypothesis.

Note, that the horizontal axis is set up with a z-score scale. Z-score indicates how many standard deviations a value is away from the mean. Zero represents the mean for the distribution of the null hypothesis. For example, a z-score of 3 indicates that the value is 3 standard deviations above the mean. A z-score of -3 would be 3 standard deviations below the mean.

Try adjusting both the standard of judgment (the dashed red line) and the position of the distribution for the alternative hypothesis and you will develop a "feeling" for how they interact. Note that a type I error is often called alpha and is equal to the p-value. The type II error is often called beta. The power of the test = (100% - beta).



Applet 1. Statistical Er

The need for unbiased, highly trained, top quality police investigators with state of the art equipment should be obvious. There is no possibility of having a type I error if the police never arrest the wrong person. Improving th accuracy of police investigations is expensive and complex but achievable in today's world with tools such as DN testing. The famous trial of O. J. Simpson would either have ended in a guilty verdict or not have occurred at all the Los Angeles Police officers investigating the crime had been beyond reproach.

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