SIGNAL DETECTION METHODOLOGY

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UC San Diego

Outline

Background

- An introduction to signal detection theory
- The distinction between response bias and discriminability

Recent applications to eyewitness identification

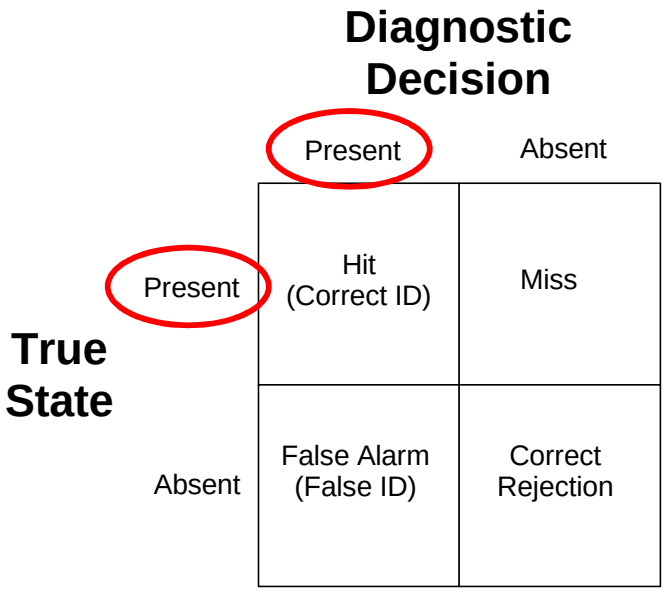
- Simultaneous vs. sequential lineups
- Understanding the relationship between eyewitness confidence and accuracy

When does signal detection theory apply?

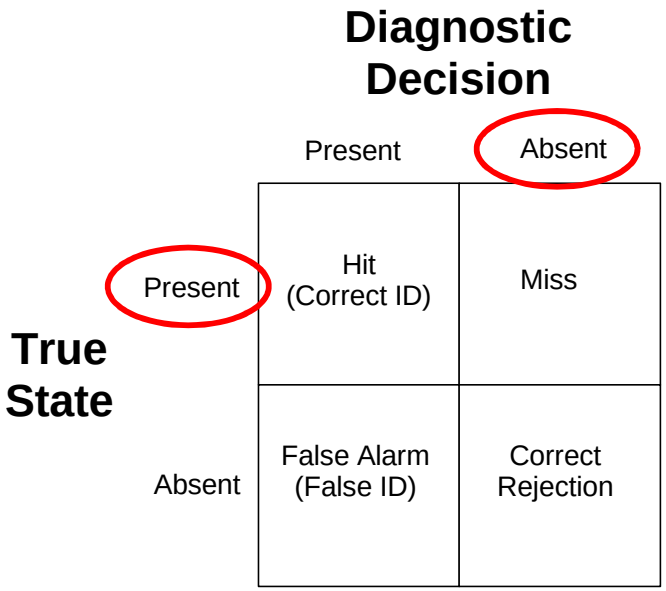
1. There are two true states of the world
   - An enemy plane is either present or absent in the sky
   - A disease is either present or absent in a patient
   - A guilty suspect is either present or absent in a lineup

2. An imperfect diagnostic procedure is used to make a decision (the target is "present" or "absent")
   - An air-defense radar system
   - A medical test
   - An eyewitness presented with a lineup

2 X 2 Table


Diagnostic Decision
Present
Absent
True State
Present
Hit (Correct ID)
Miss
Absent
False Alarm (False ID)
Correct Rejection

2 X 2 Table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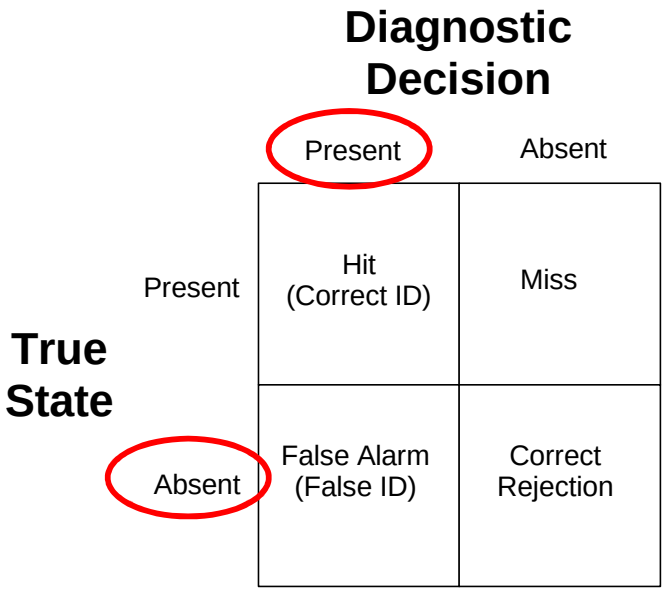
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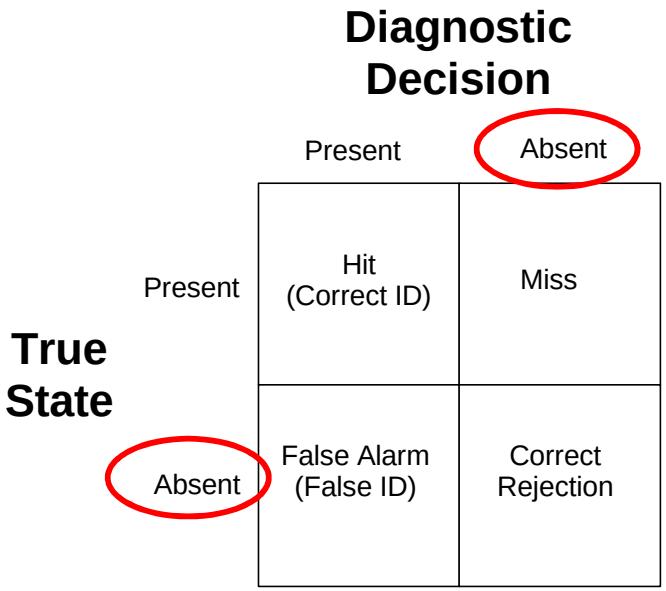
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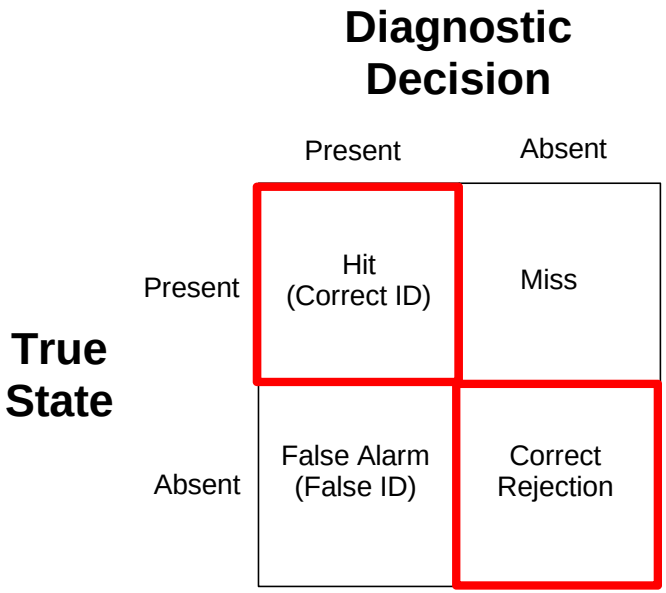
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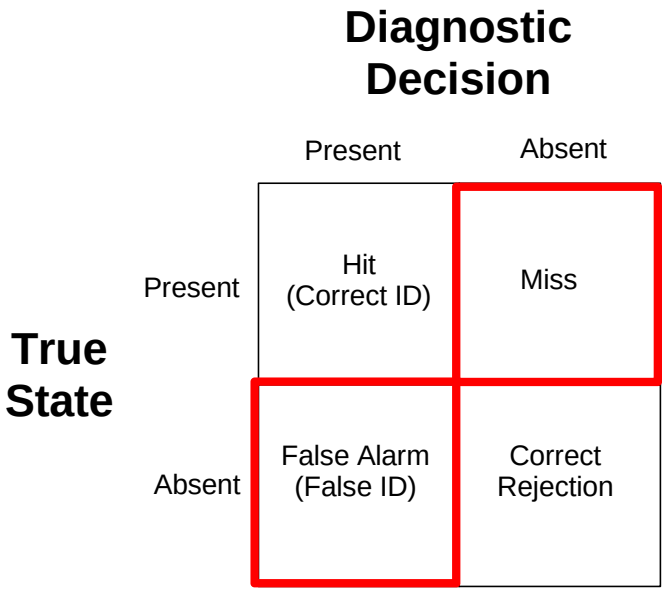
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2 X 2 Table

Ted Bundy

True State \ Diagnostic Decision	Present	Absent
Present	Hit (Correct ID)	Miss
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Innocence Project

Ronald Cotton

2 X 2 Table

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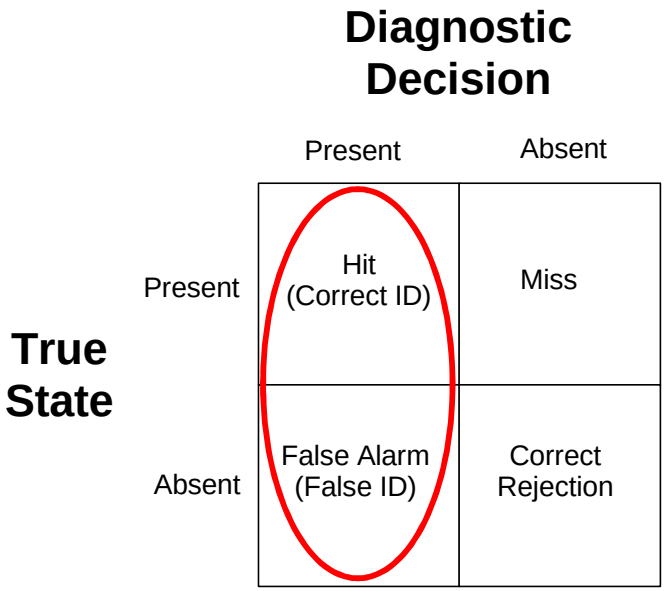
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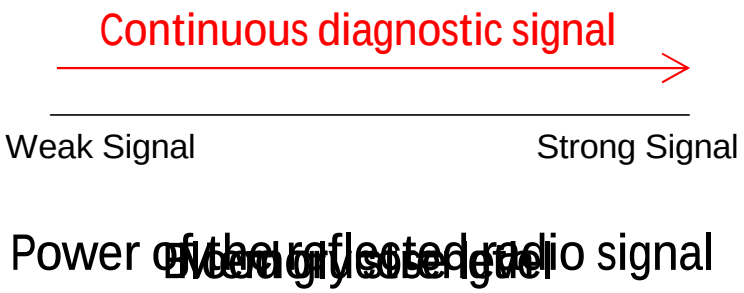
Signal Detection Theory



Signal Detection Theory: Response Bias

"the guilty suspect is probably in the lineup"

Weak Signal — Strong Signal

Signal Detection Theory: Response Bias

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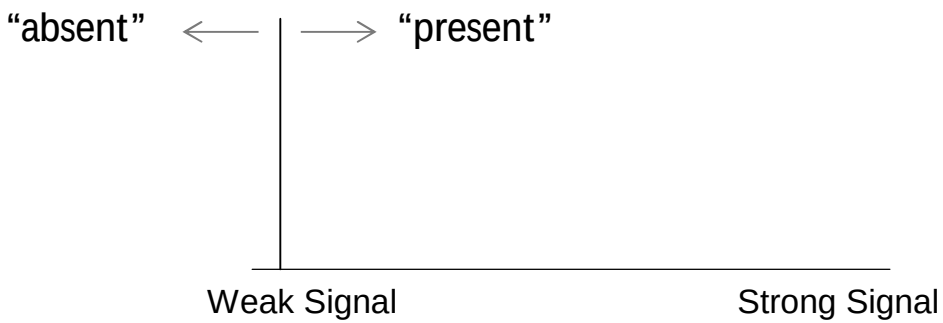

Liberal response bias:
Identify even if confidence is low

Signal Detection Theory: Response Bias

"the guilty suspect may or may not be in the lineup"

Weak Signal — Strong Signal

Signal Detection Theory: Response Bias

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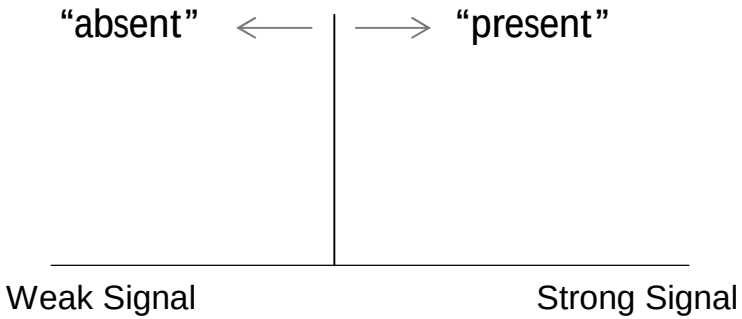


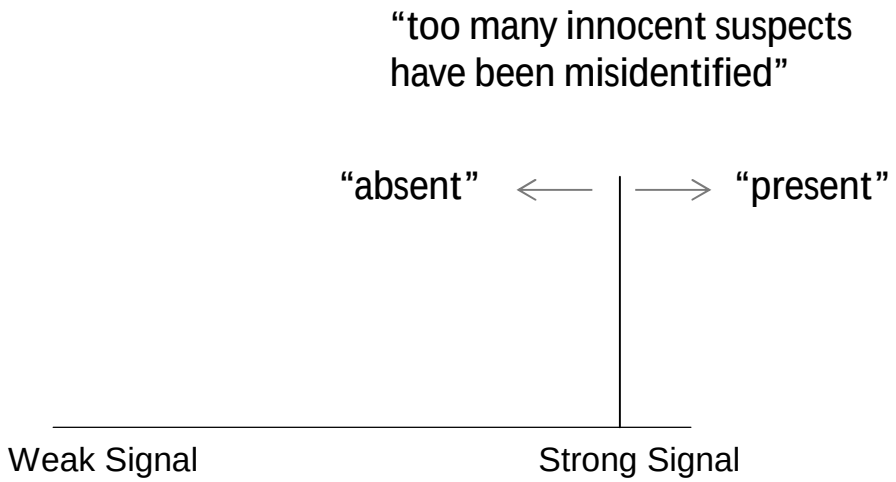
Neutral response bias:
Identify if confidence is fairly high

Signal Detection Theory: Response Bias

"too many innocent suspects have been misidentified"

Weak Signal — Strong Signal

Signal Detection Theory: Response Bias



Conservative response bias:
Identify only if confidence is very high

Signal Detection Theory: Discriminability

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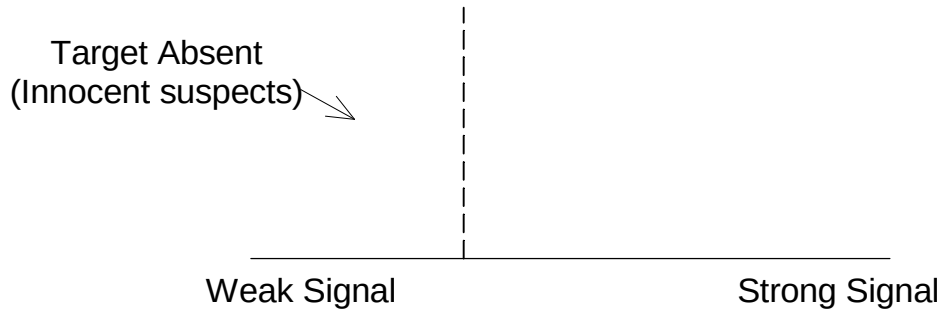

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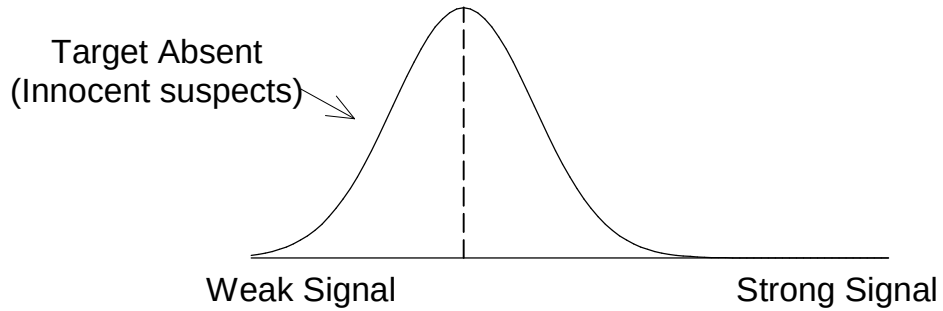

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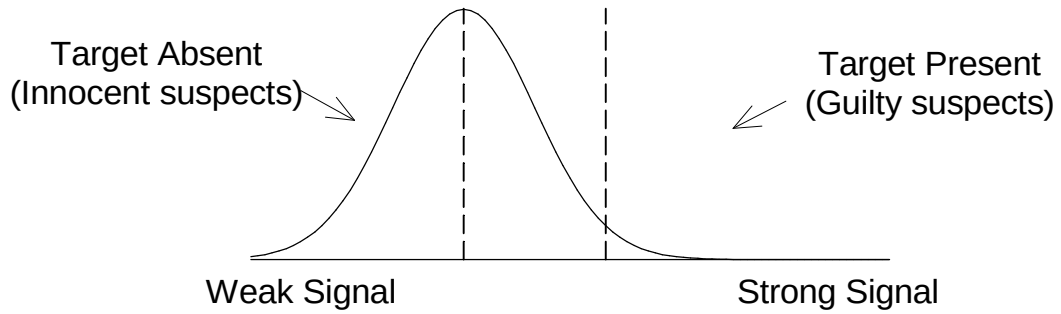
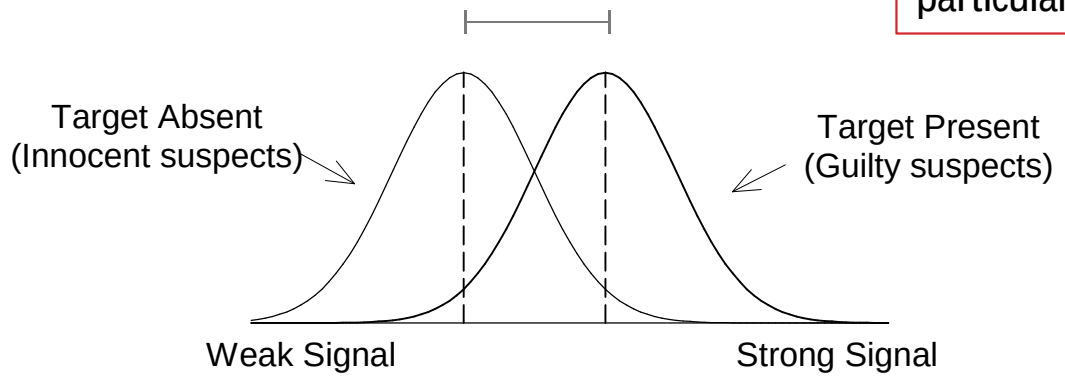
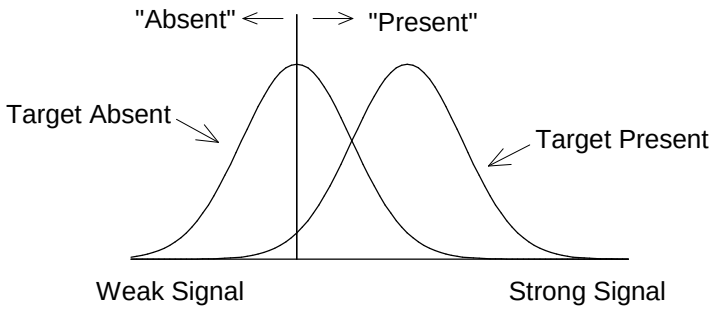


Signal Detection Theory: Discriminability

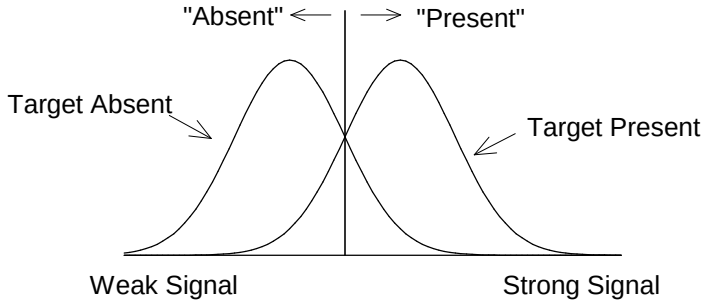
The degree to which the memory signals associated with innocent and guilty suspects are separated using a particular diagnostic procedure



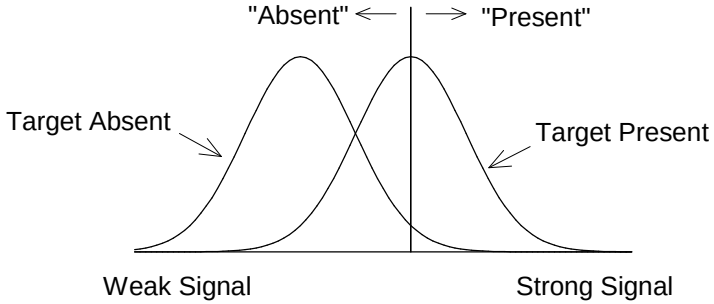
Liberal



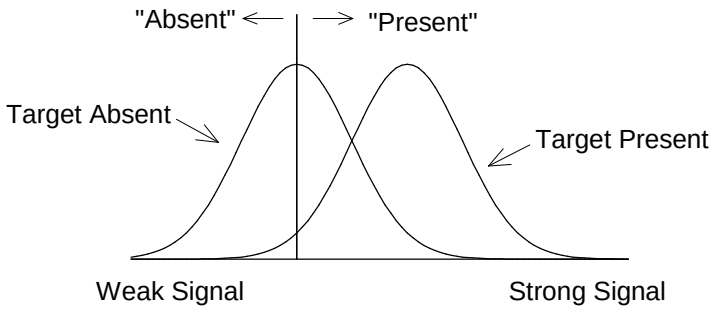
Neutral

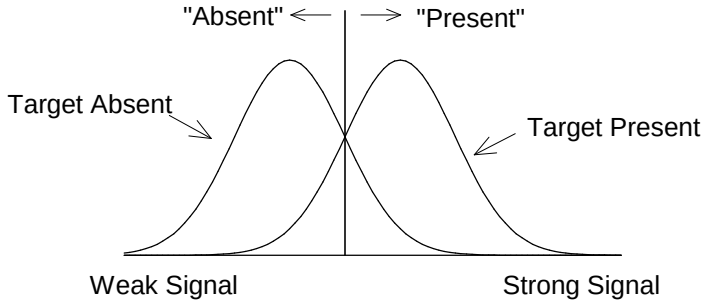


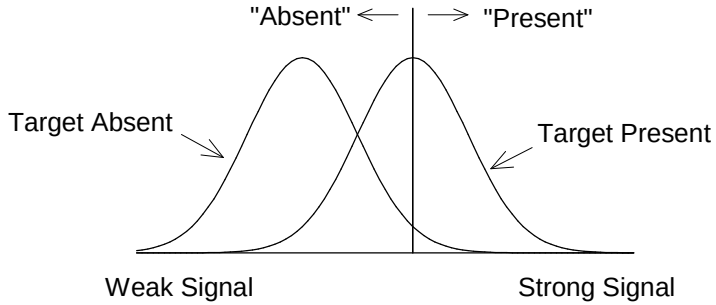
Conservative



Liberal: “the guilty suspect is probably in the lineup”







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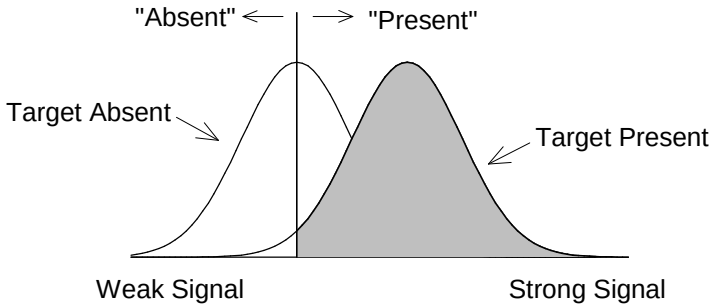
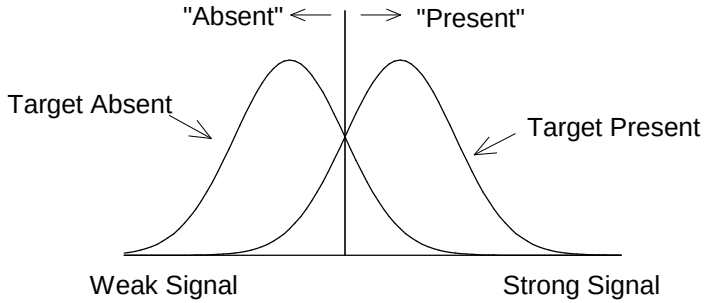
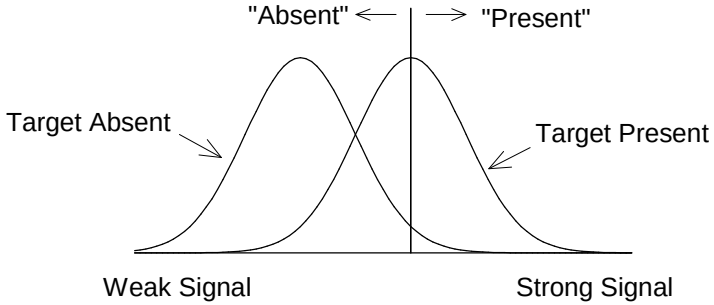


Correct ID Rate = 0.98





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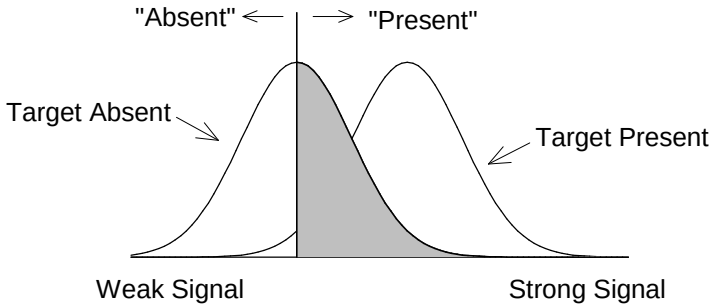
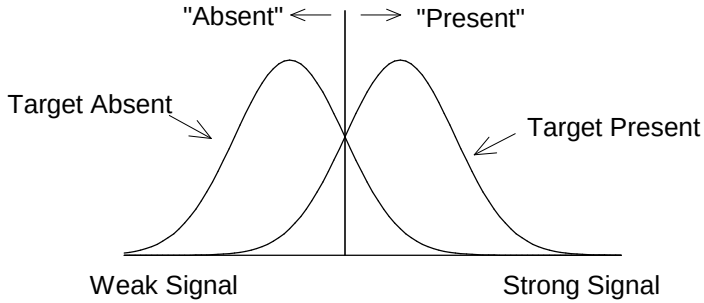
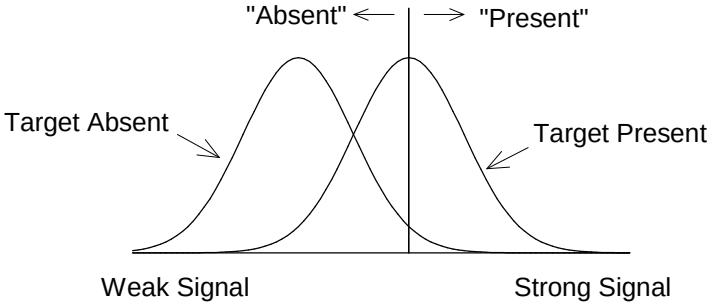
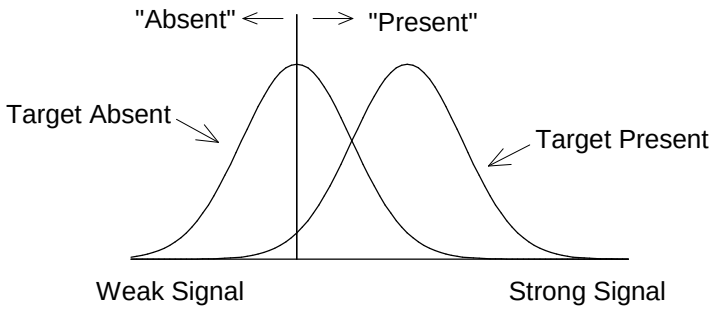


Correct ID Rate = 0.98

False ID Rate = 0.50







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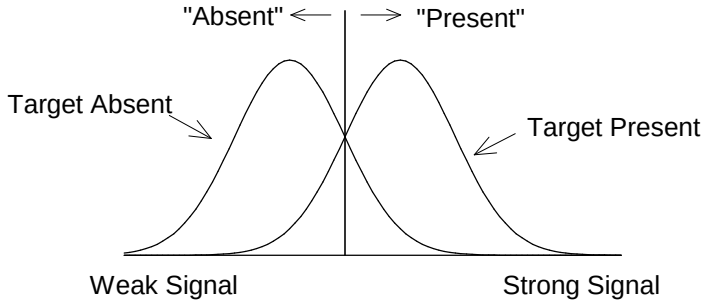

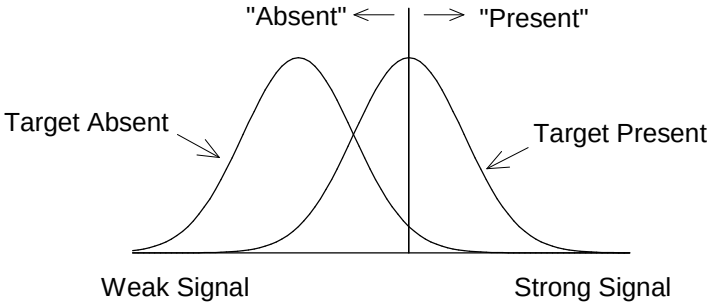

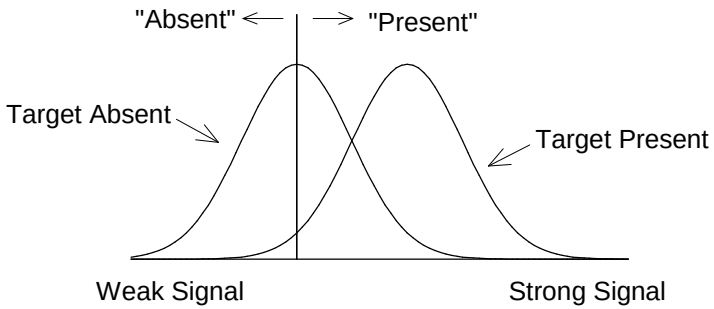

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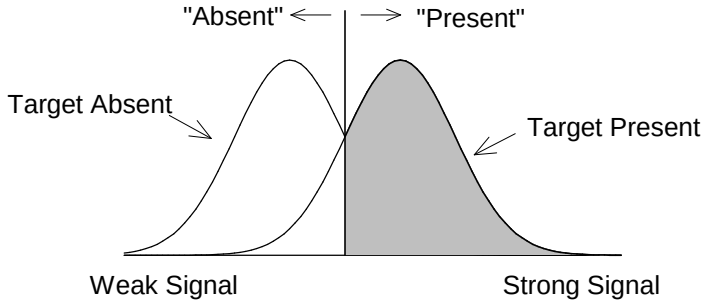

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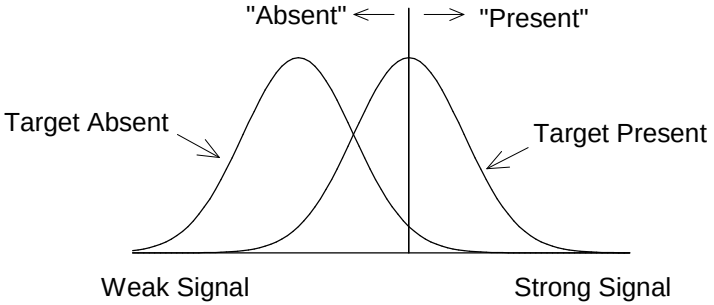

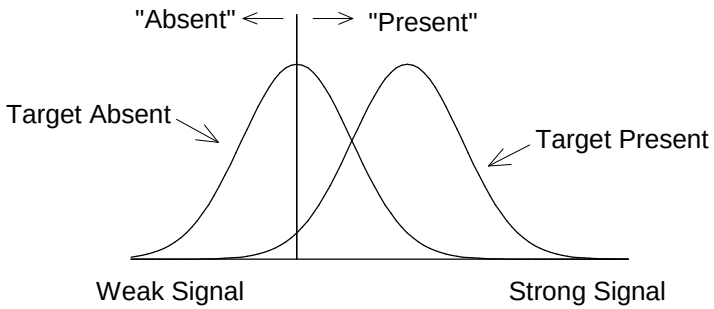

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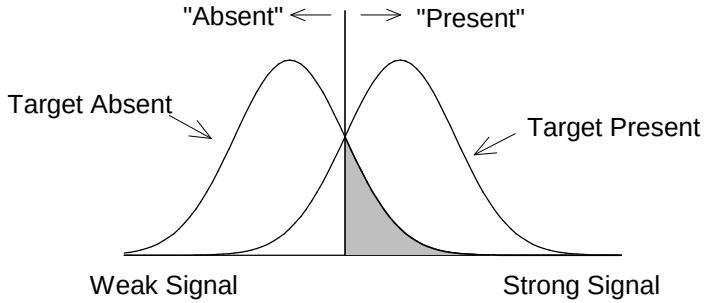
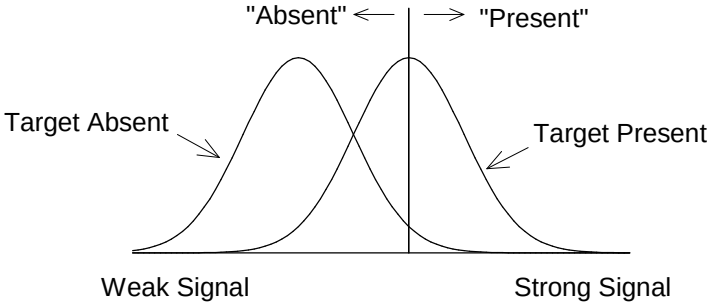
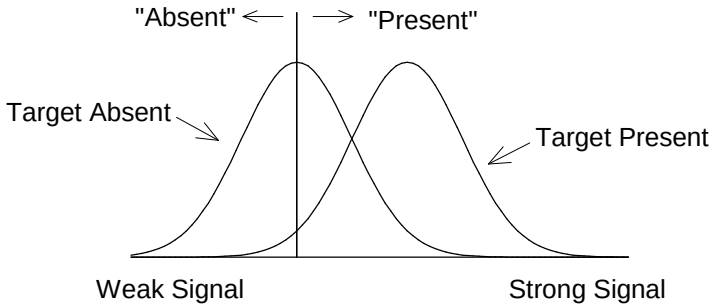
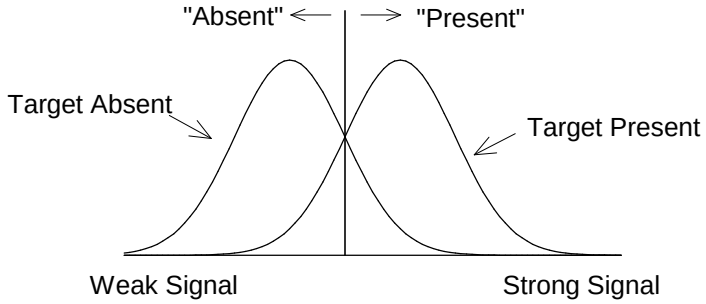


Correct ID Rate = 0.84

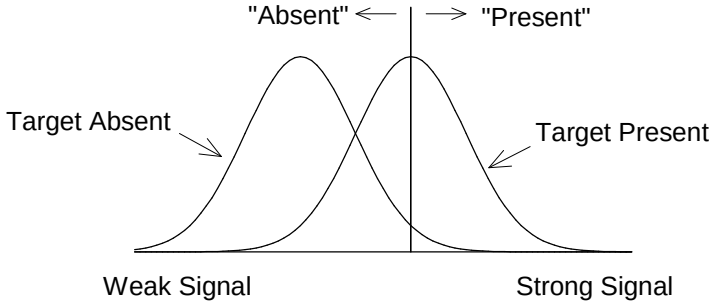
False ID Rate = 0.16

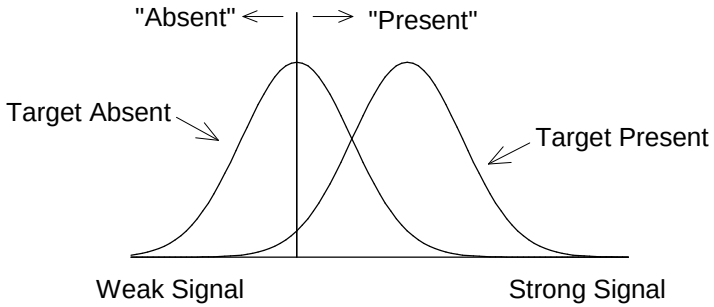


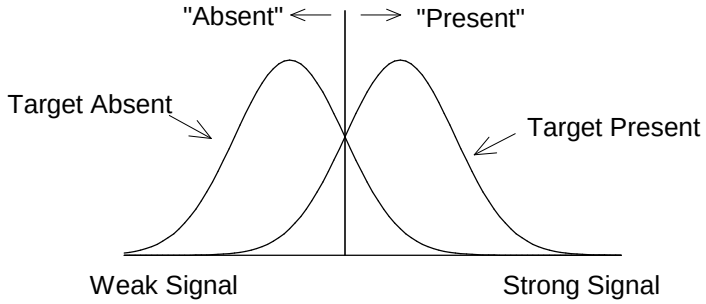




Conservative: “do not make an ID unless you are certain of being correct”







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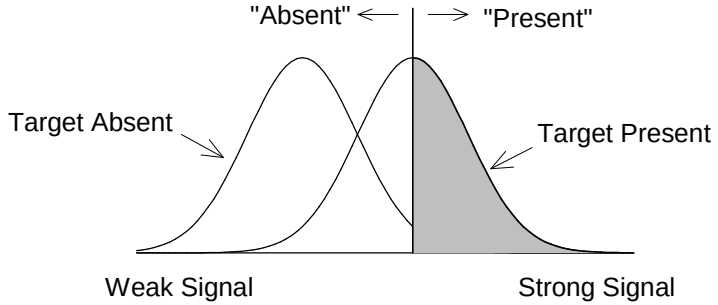
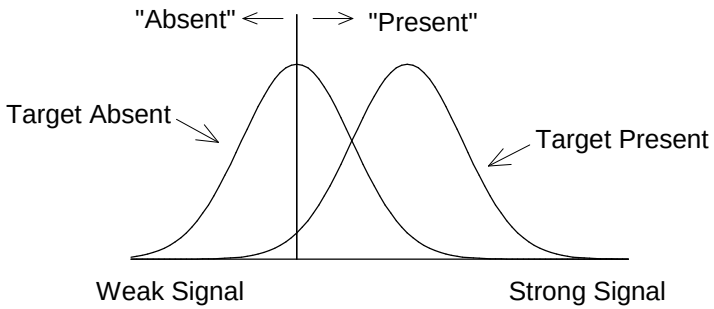
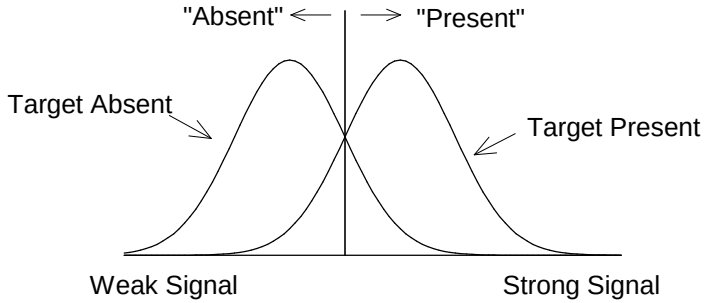


Correct ID Rate = 0.50





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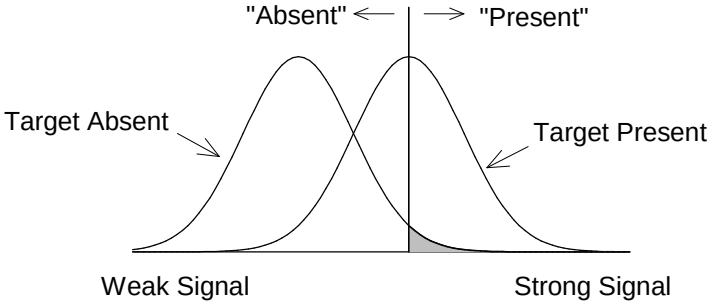
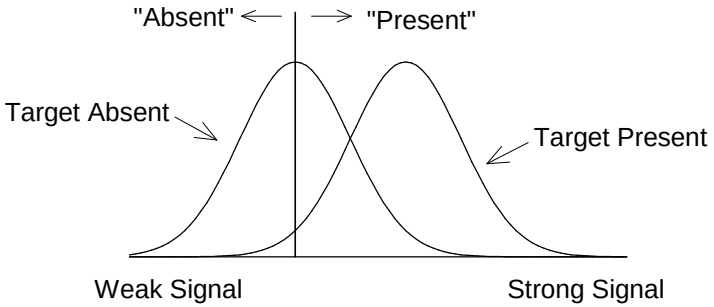


Correct ID Rate = 0.50

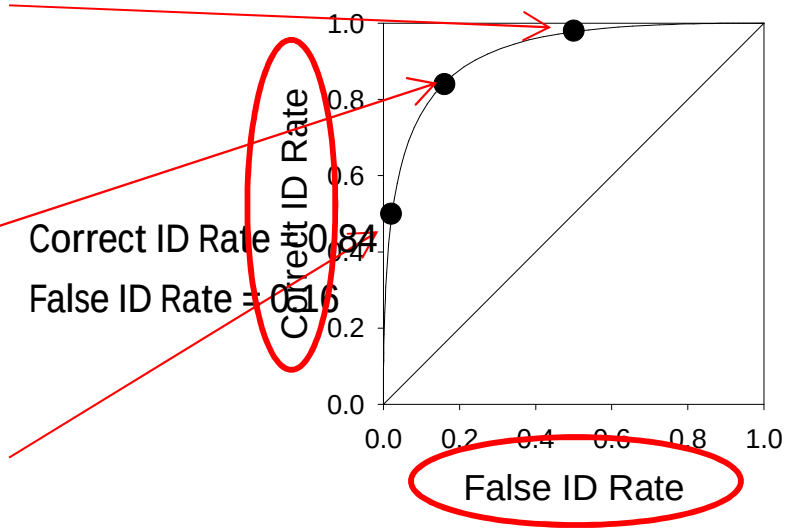
False ID Rate = 0.02

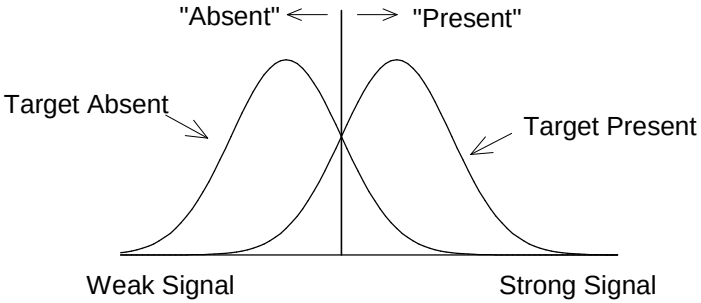


Correct ID Rate = 0.98

False ID Rate = 0.50

Receiver Operating Characteristic (ROC)





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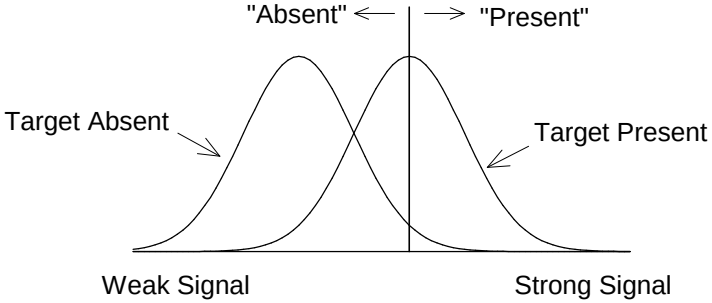

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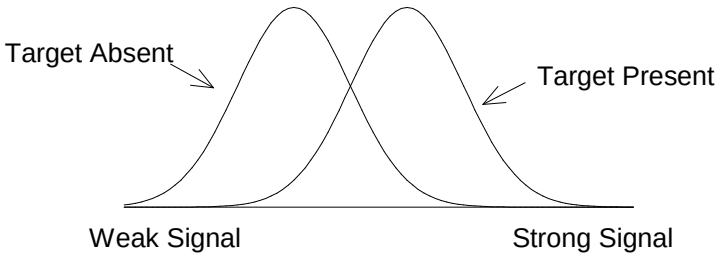
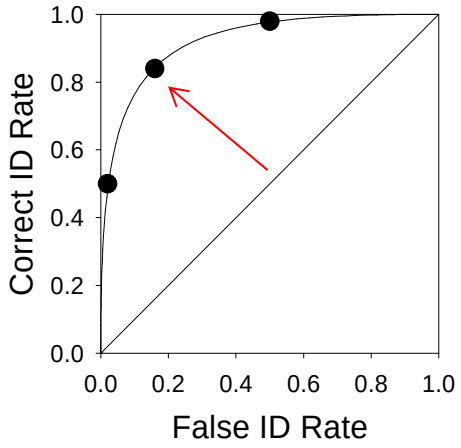
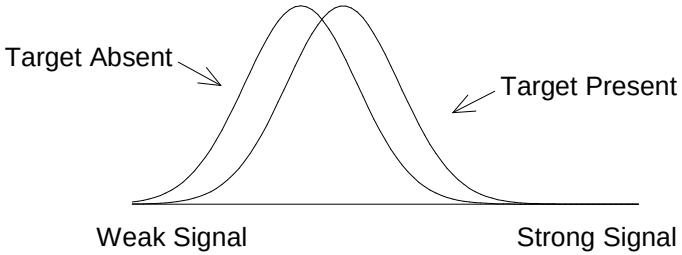
False ID Rate = 0.02

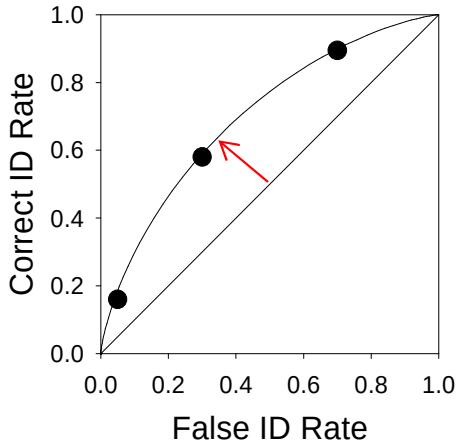
Receiver Operating Characteristic Analysis





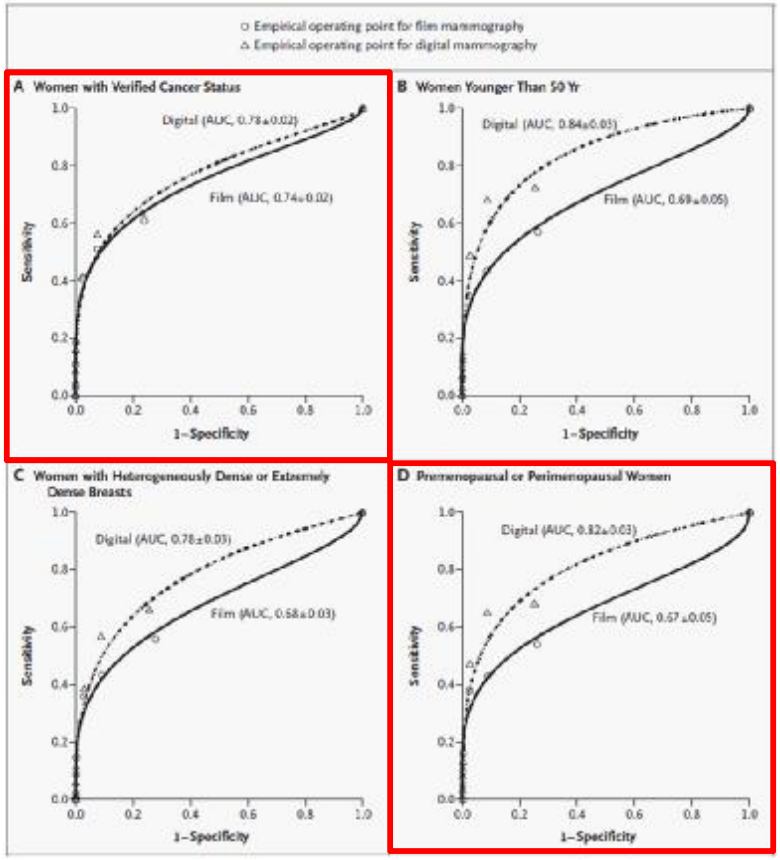
High discriminability





Low discriminability

Pisano, E. D., Gatsonis, C., Hendrick, E. et al. (2005). Diagnostic performance of digital versus film mammography for breast-cancer screening. *The New England Journal of Medicine, 353*, 1773-1783.



Eyewitness Identification

Eyewitness Identification Procedures

Simultaneous Lineup

Sequential Lineup

Lindsay & Wells (1985)

- Simultaneous lineup
  - Correct ID rate = 0.58
  - False ID rate = 0.43
- Sequential lineup
  - Correct ID rate = 0.50
  - False ID rate = 0.17

Clark (2012, *Perspectives on Psychological Science*)

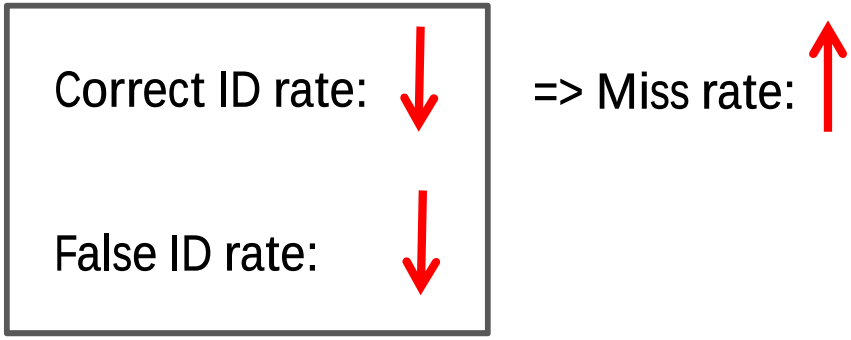
- Simultaneous lineup
  - Correct ID rate = 0.54
  - False ID rate = 0.15
- Sequential lineup
  - Correct ID rate = 0.43
  - False ID rate = 0.09

"…roughly equivalent decreases in both correct and false identification rates" (Clark, 2012)

Lindsay & Wells (1985)

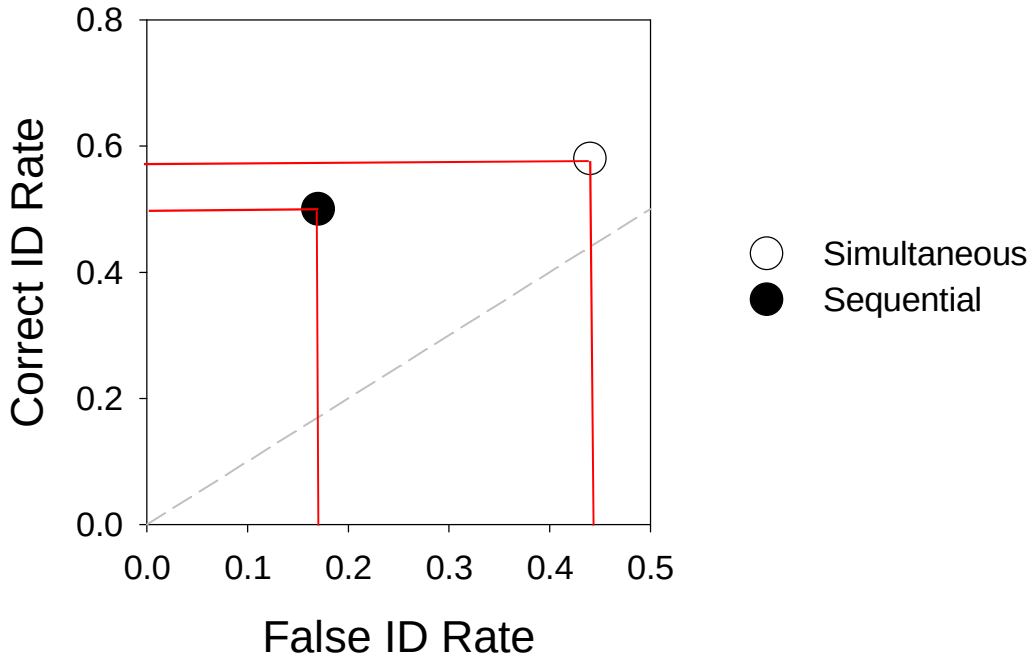
- Simultaneous lineup
  - Correct ID rate = 0.58
  - False ID rate = 0.43
- Sequential lineup
  - Correct ID rate = 0.50
  - False ID rate = 0.17

"…the sequential lineup reduced the rate of identifying the culprit by only 8% but reduced choosing in the culprit-absent lineup by 22%" (Steblay, Dysart & Wells, 2011, *Psychology, Public Policy, and Law*).



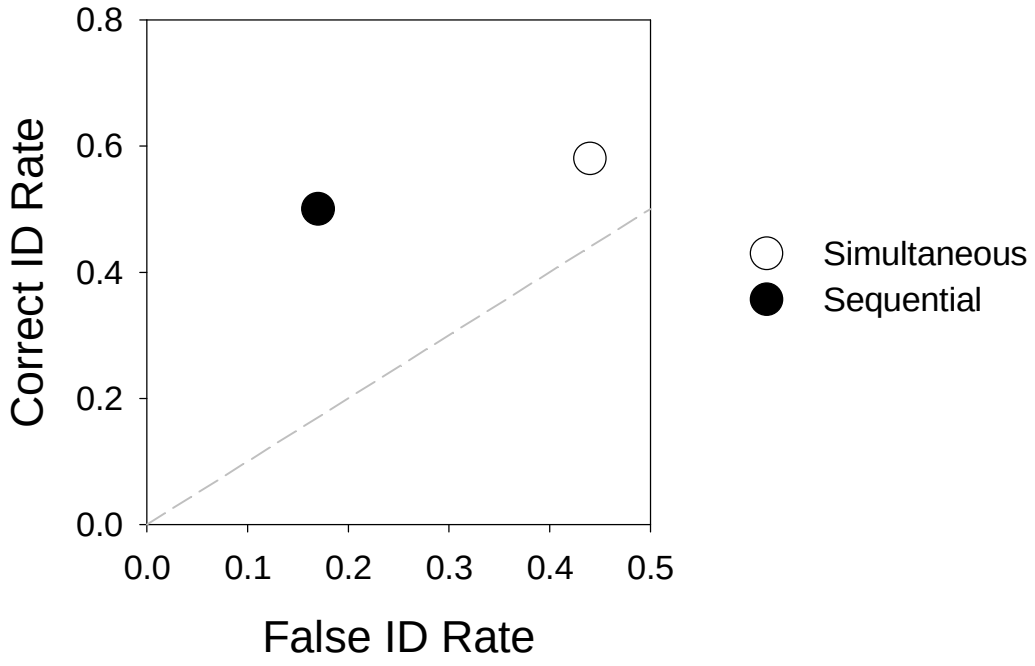
Lindsay & Wells (1985)

Lineup Format	Correct ID Rate	False ID Rate
Simultaneous	0.58	0.43
Sequential	0.5	0.17



Lindsay & Wells (1985)

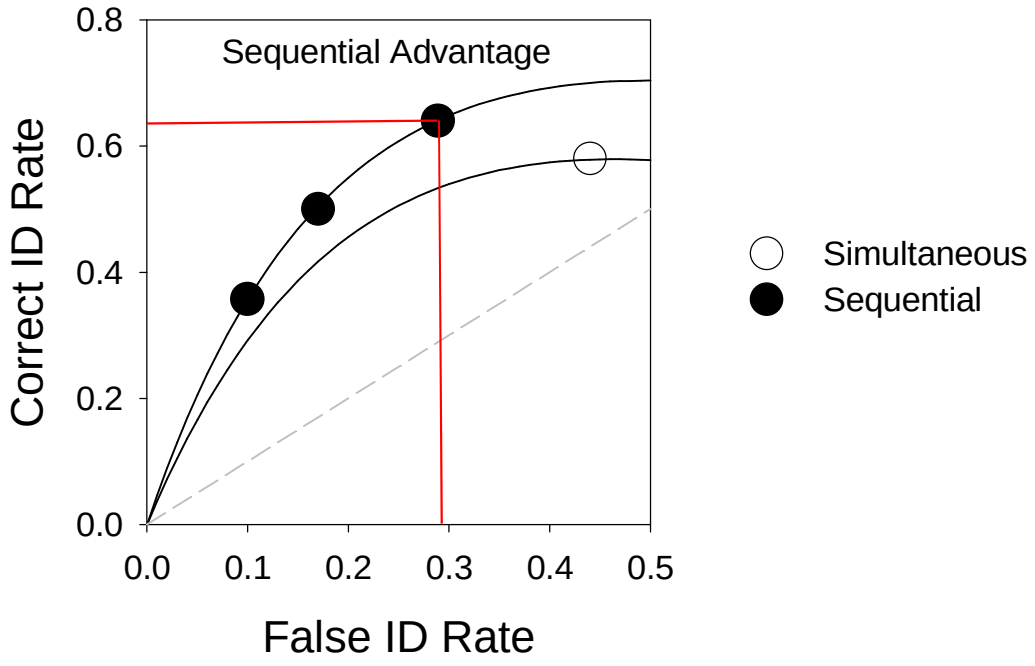
Lineup Format	Correct ID Rate	False ID Rate
Simultaneous	0.58	0.43
Sequential	0.5	0.17



Gronlund, Wixted & Mickes (in press)

Lindsay & Wells (1985)

Lineup Format	Correct ID Rate	False ID Rate
Simultaneous	0.58	0.43
Sequential	0.5	0.17



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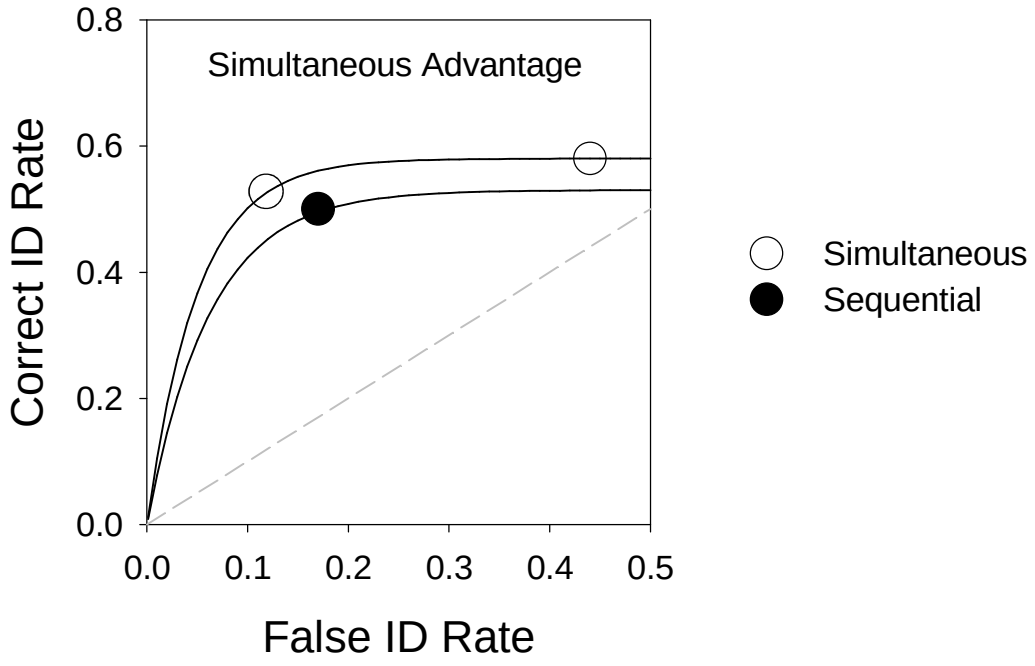

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Lineup Format	Correct ID Rate	False ID Rate
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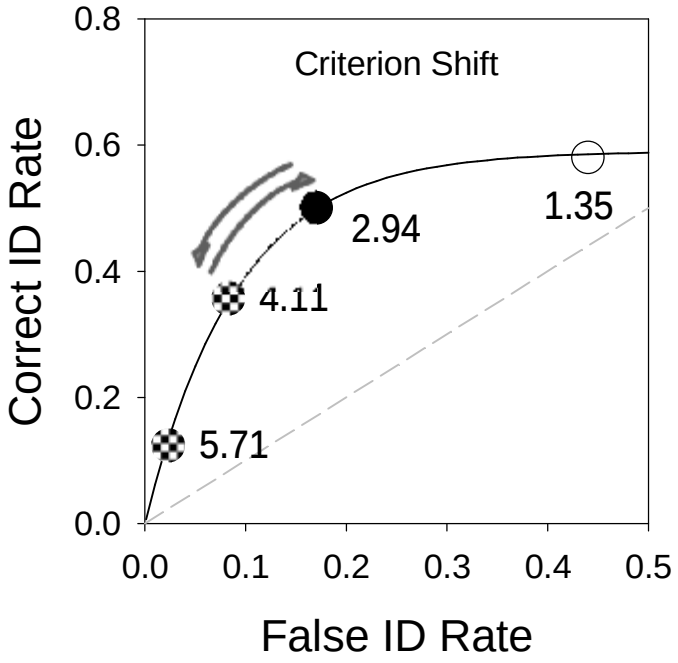

Probative value:
Correct ID rate / False ID rate

An ID made using the lineup procedure with higher probative value is more diagnostic of guilt

Gronlund, Wixted & Mickes (in press)

Lindsay & Wells (1985)

Lineup Format	Correct ID Rate	False ID Rate
Simultaneous	0.58	0.43
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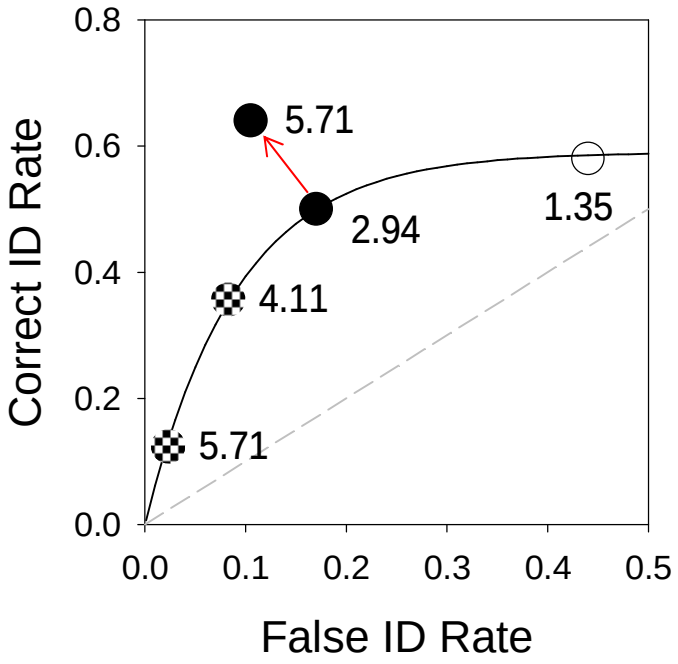

Probative value:
Correct ID rate / False ID rate

An ID made using the lineup procedure with higher probative value is more diagnostic of guilt

○ Simultaneous
● Sequential

Gronlund, Wixted & Mickes (in press)

Lindsay & Wells (1985)

Lineup Format	Correct ID Rate	False ID Rate
Simultaneous	0.58	0.43
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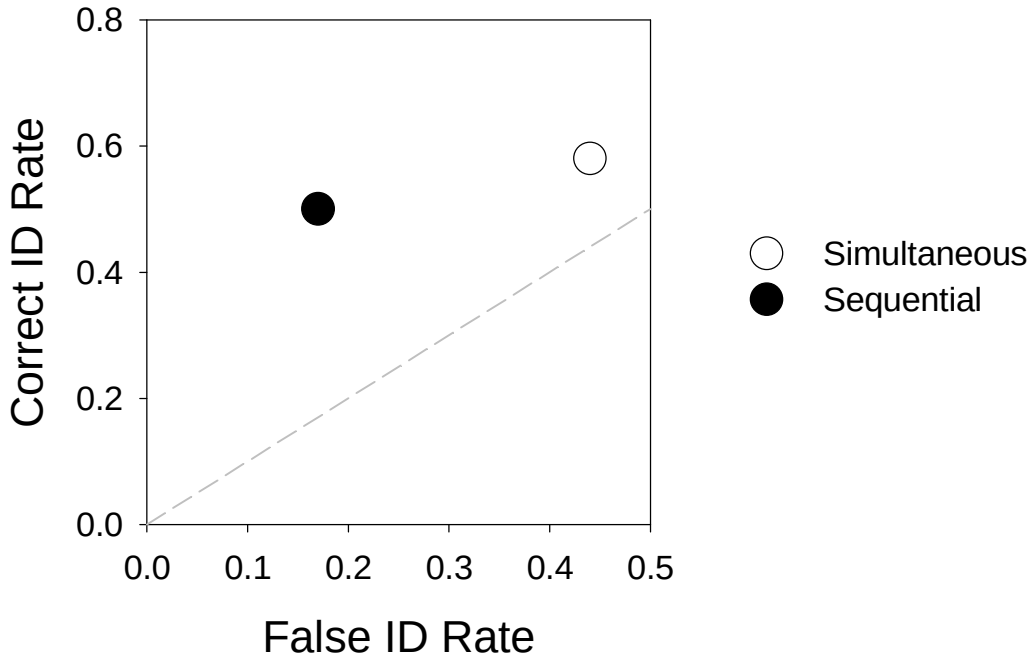

Gronlund, Wixted & Mickes (in press)

SAVING WOMEN'S LIVES

Strategies for Improving Breast Cancer Detection and Diagnosis

Committee on New Approaches to Early Detection
and Diagnosis of Breast Cancer

National Cancer Policy Board

Board on Science, Technology, and Economic Policy
Policy and Global Affairs Division

Janet E. Joy, Edward E. Penhoet, and Diana B. Petitti, *Editors*

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Appendix C

ROC Analysis: Key Statistical Tool for Evaluating Detection Technologies

ROC analysis provides a systematic tool for quantifying the impact of variability among individuals' decision thresholds. The term receiver operating characteristic (ROC) originates from the use of radar during World War II. Just as American soldiers deciphered a blip on the radar screen as a German bomber, a friendly plane, or just noise, radiologists face the task of identifying abnormal tissue against a complicated background. As radar technology advanced during the war, the need for a standard system to evaluate detection accuracy became apparent. ROC analysis was developed as a standard methodology to quantify a signal receiver's ability to correctly distinguish objects of interest from the background noise in the system.

For instance, each radiologist has his or her own visual clues guiding them to a clinical decision as whether the pattern variation of a mammogram indicates tissue abnormalities or just normal variation. The varying decisions make up a range of decision thresholds.

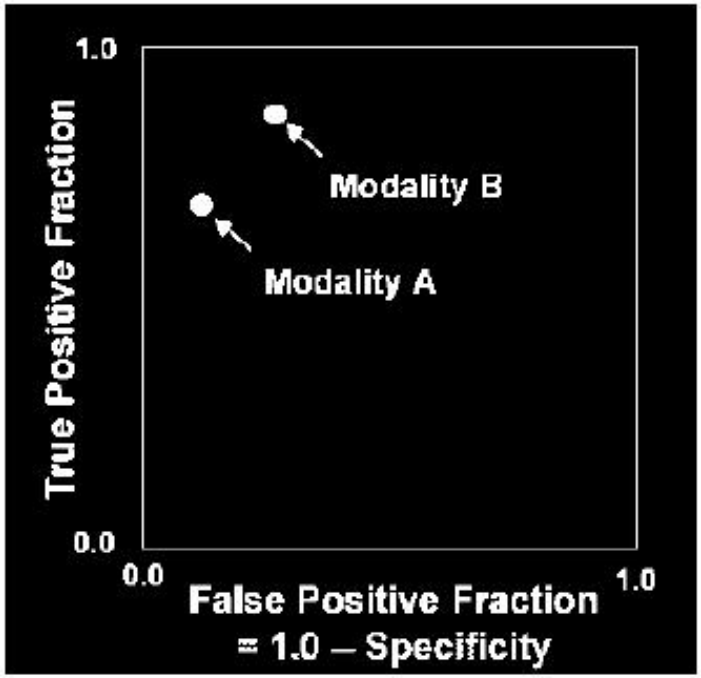


FIGURE C-3 Comparison of two diagnostic modalities without ROC curves. Without the help of ROC curves it is difficult to reach a conclusion as to which modality is more accurate.

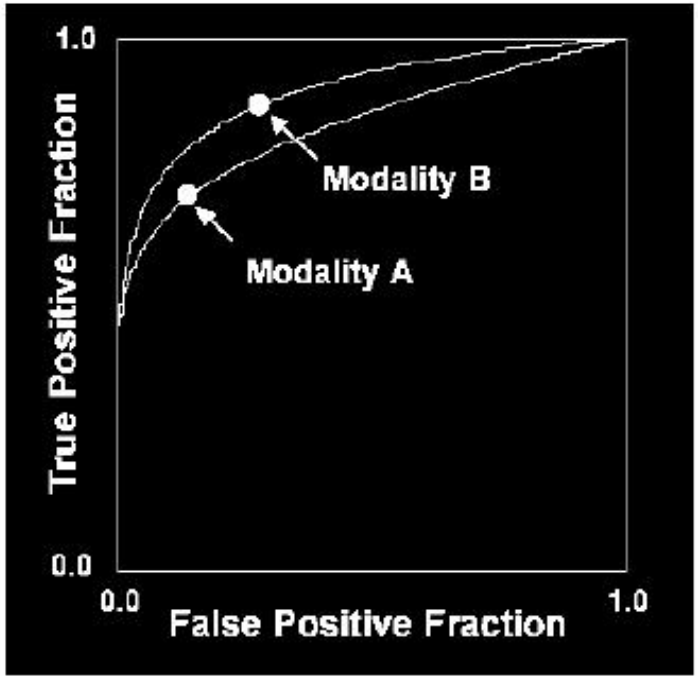


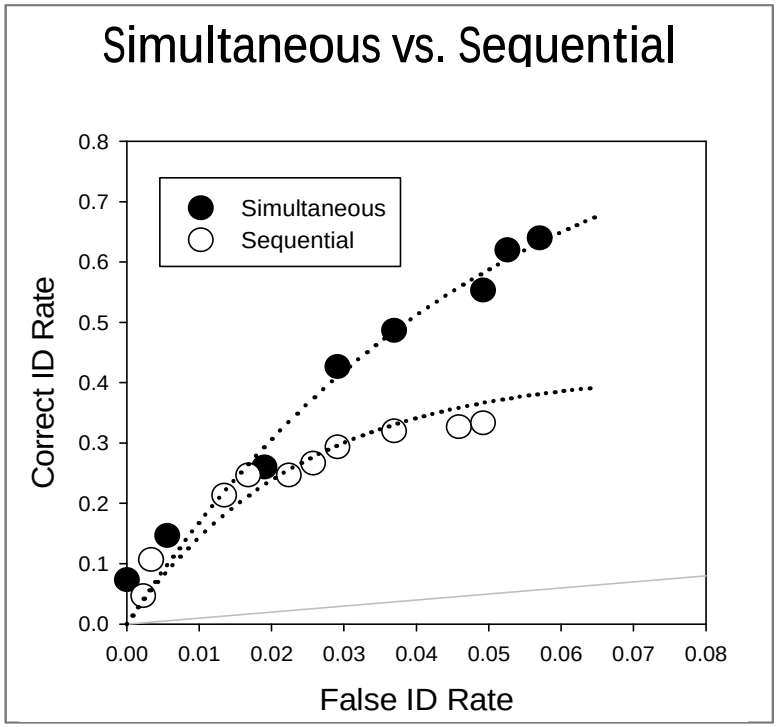
FIGURE C-4 Comparison of two diagnostic modalities utilizing ROC curves. After drawing ROC curves it is easy to see that modality B is better. Modality B achieves a higher true-positive fraction at the same false-positive fraction as modality A. Modality B also results in a lower false-positive fraction with the same true-positive fraction as modality A.

Application # 1: Simultaneous vs. Sequential Lineups

Simultaneous Lineup

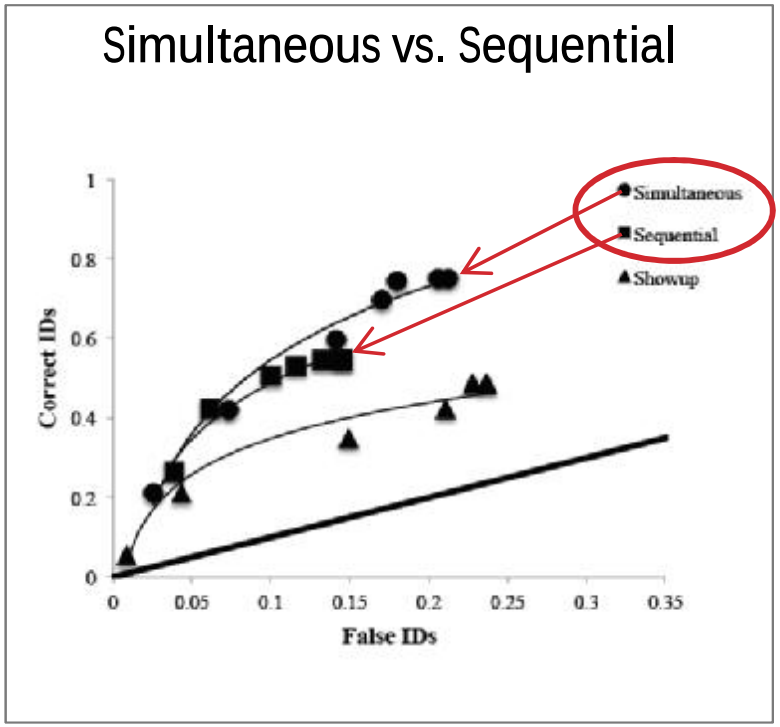
Sequential Lineup

Results from ROC Analysis



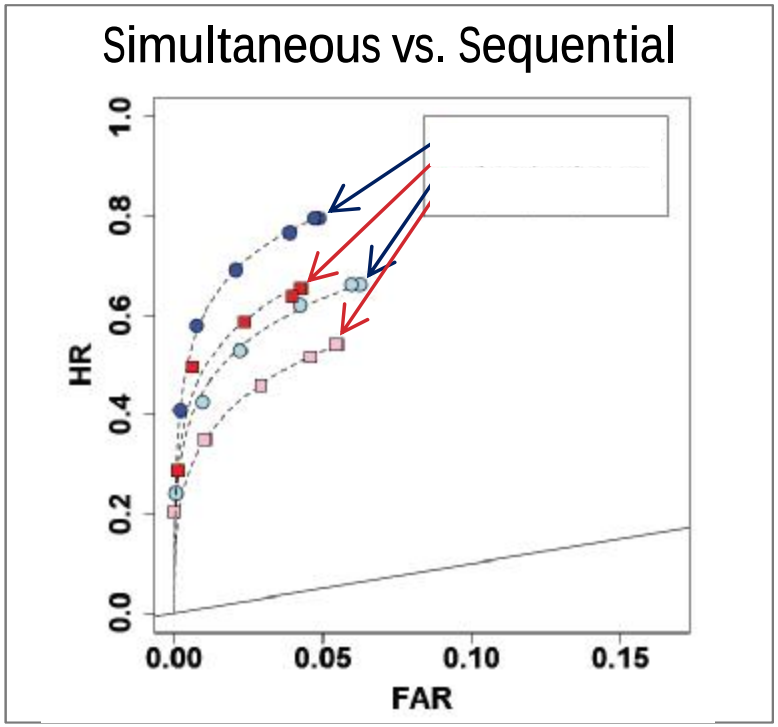
Mickes, Flowe, & Wixted (2012)

Results from ROC Analysis (lab #2)



Gronlund et al. (2012)

Results from ROC Analysis (lab #3)

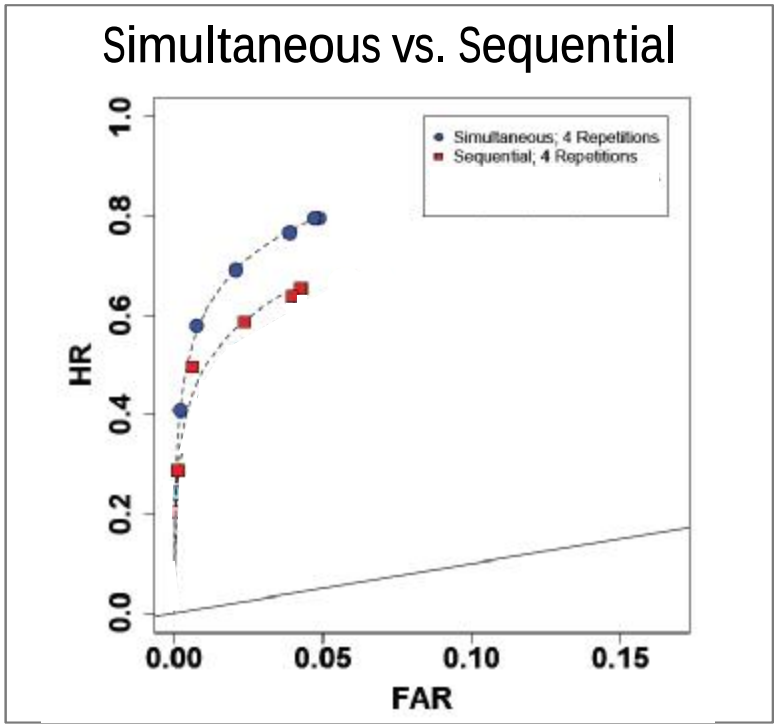


Dobolyi & Dodson (2013)

Results from ROC Analysis (lab #3)

Take-home message #1:

"ROC analysis: Key statistical tool for evaluating detection technologies" [for any eyewitness reform that reduces both the false ID rate and the correct ID rate]



Dobolyi & Dodson (2013)

Results from ROC Analysis (lab #3)

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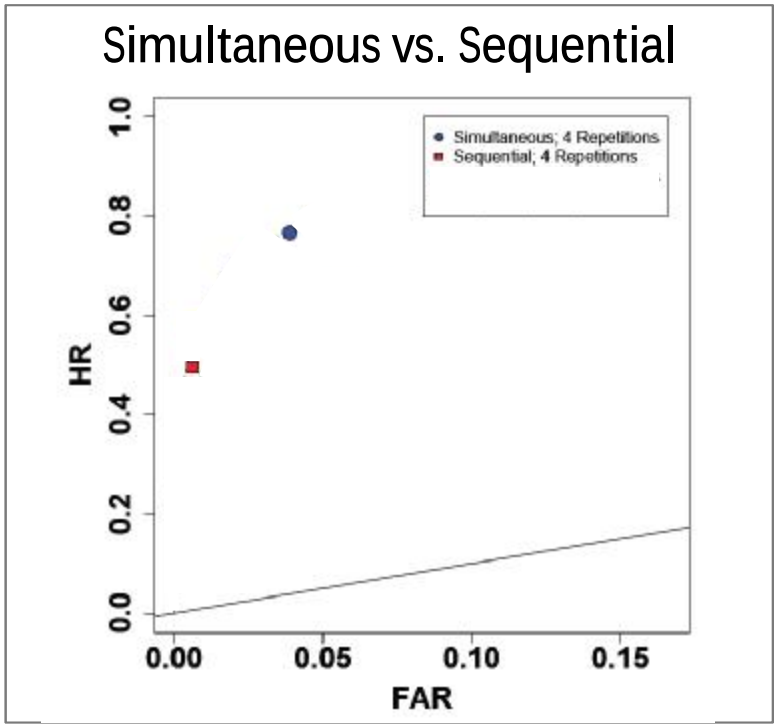
"ROC analysis: Key statistical tool for evaluating detection technologies" [for any eyewitness reform that reduces both the false ID rate and the correct ID rate]



Dobolyi & Dodson (2013)

Results from ROC Analysis (lab #3)

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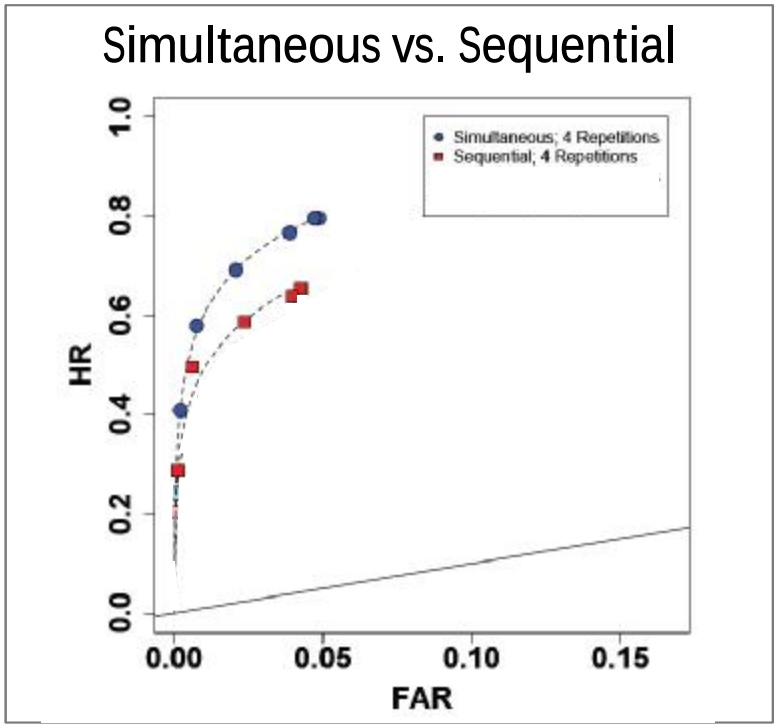
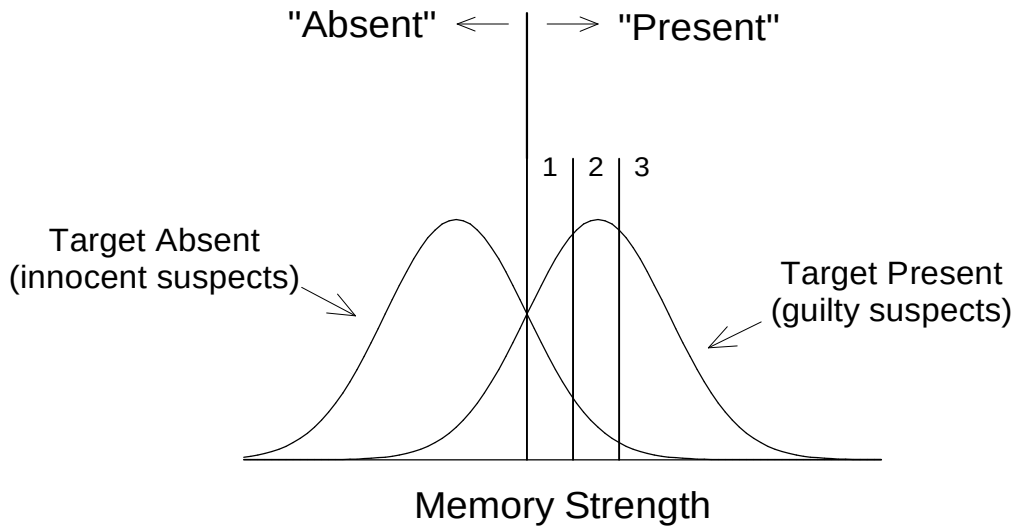
"ROC analysis: Key statistical tool for evaluating detection technologies" [for any eyewitness reform that reduces both the false ID rate and the correct ID rate]



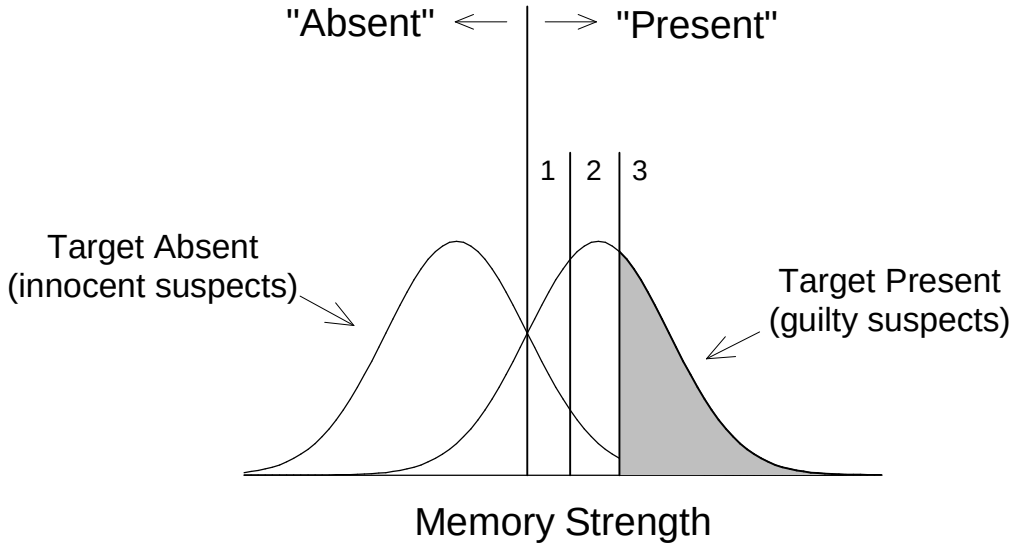
Dobolyi & Dodson (2013)

Application #2: The relationship between eyewitness confidence and accuracy



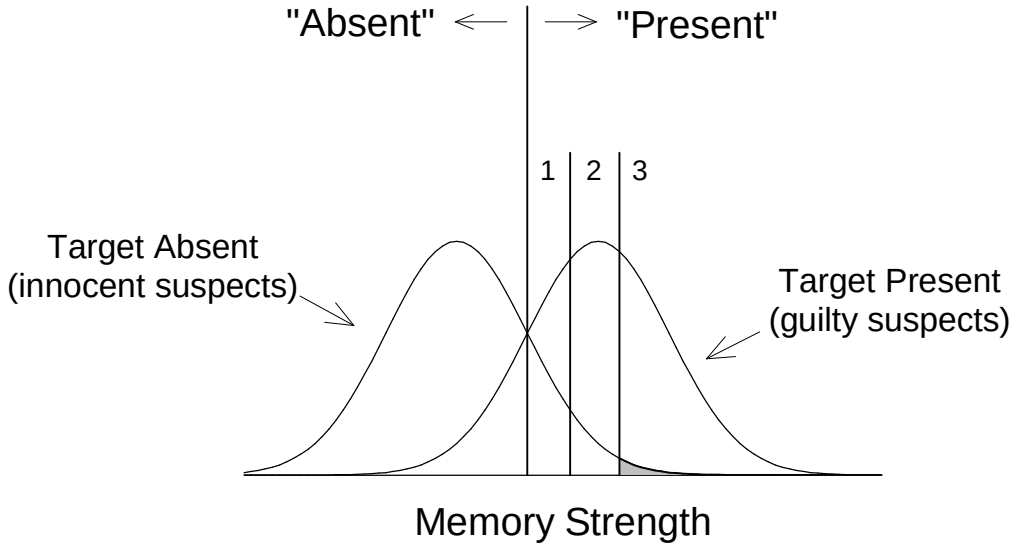
1= Low confidence
2 = Medium confidence
3 = High confidence

The relationship between eyewitness confidence and accuracy



High-confidence
correct ID rate = 0.38

The relationship between eyewitness confidence and accuracy

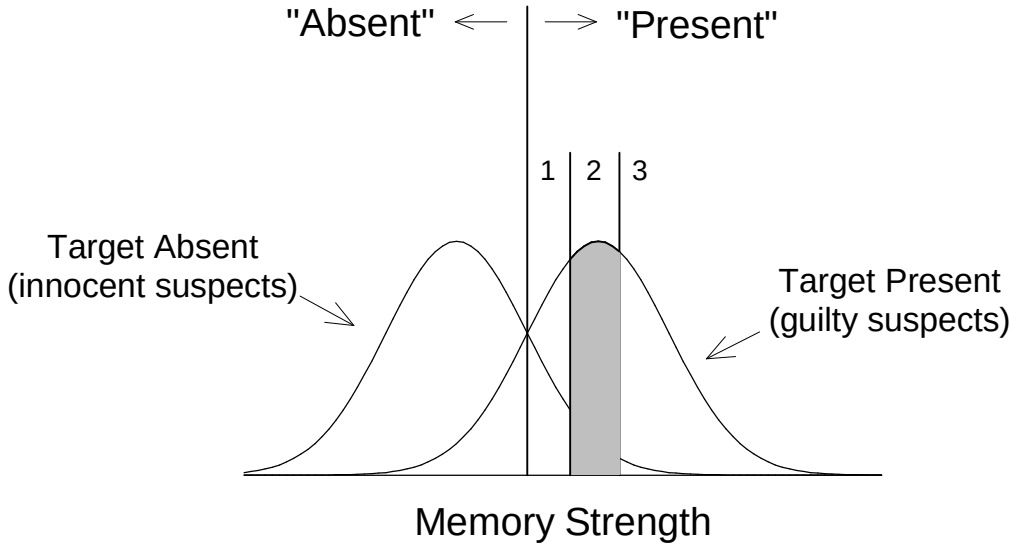


High-confidence correct ID rate = 0.38

High-confidence false ID rate = 0.01

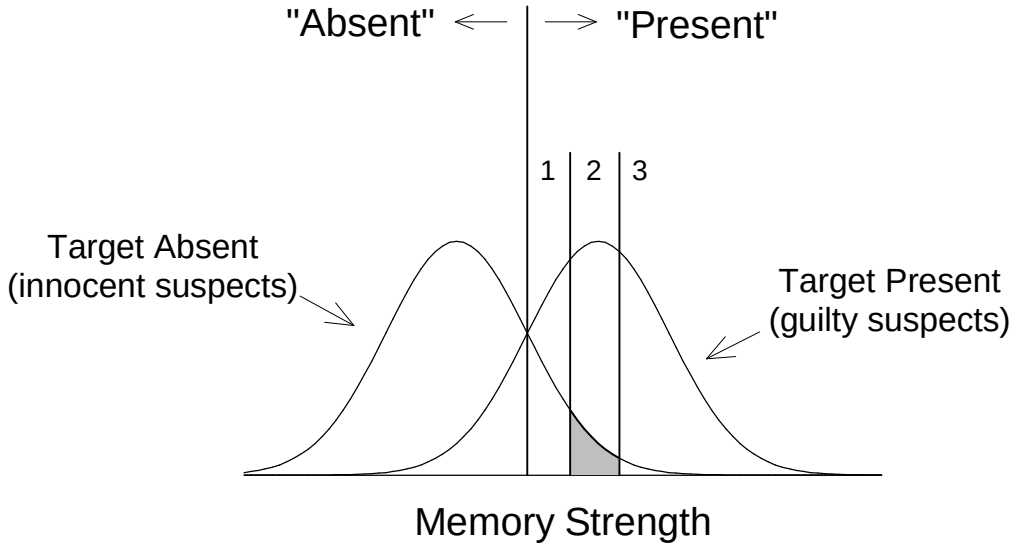
High-confidence accuracy = 97% correct

The relationship between eyewitness confidence and accuracy



Medium-confidence
correct ID rate = 0.27

The relationship between eyewitness confidence and accuracy

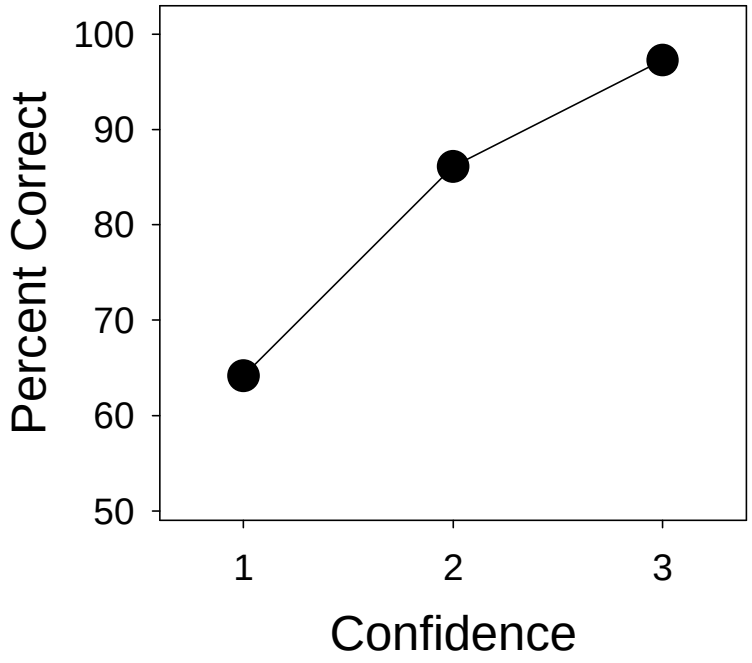


Medium-confidence correct ID rate = 0.27

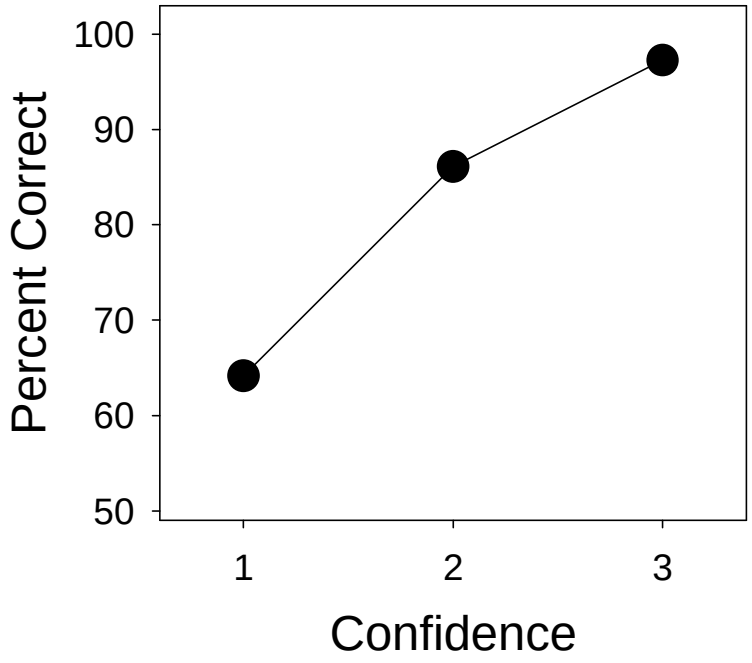
Medium-confidence false ID rate = 0.044

Medium-confidence accuracy = 86% correct

The relationship between eyewitness confidence and accuracy



The relationship between eyewitness confidence and accuracy



The relationship between eyewitness confidence and accuracy

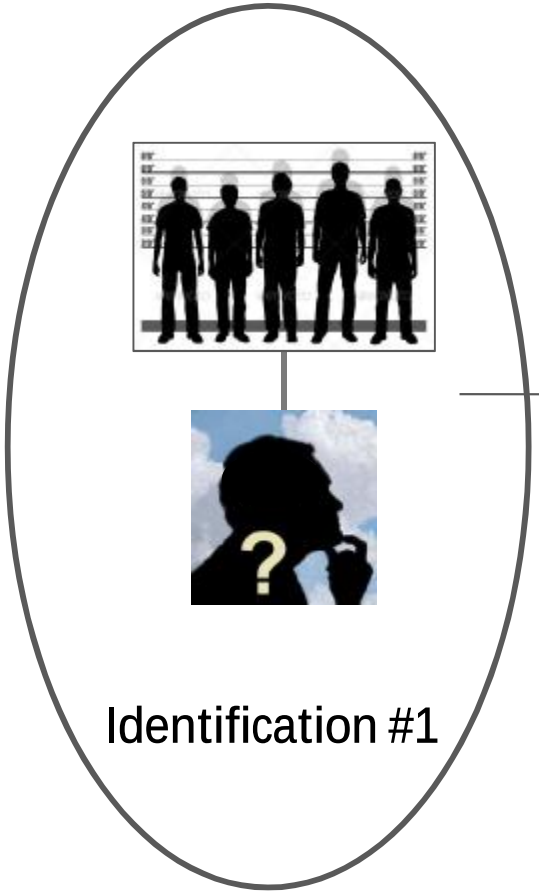
Months later

"I am 100% sure"

Identification #1

Identification #2

The relationship between eyewitness confidence and accuracy



Months later

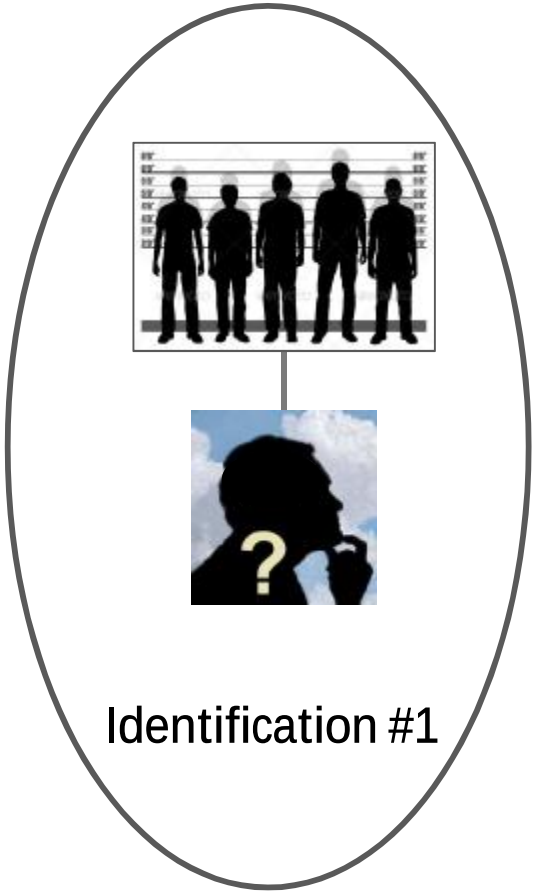
Numerous post-ID factors increase confidence without increasing accuracy (Elizabeth Loftus, Gary Wells), perhaps to the point of eliminating the diagnosticity of the memory signal

This memory test is analogous to investigating a crime scene long after it was contaminated

"I am 100% sure"

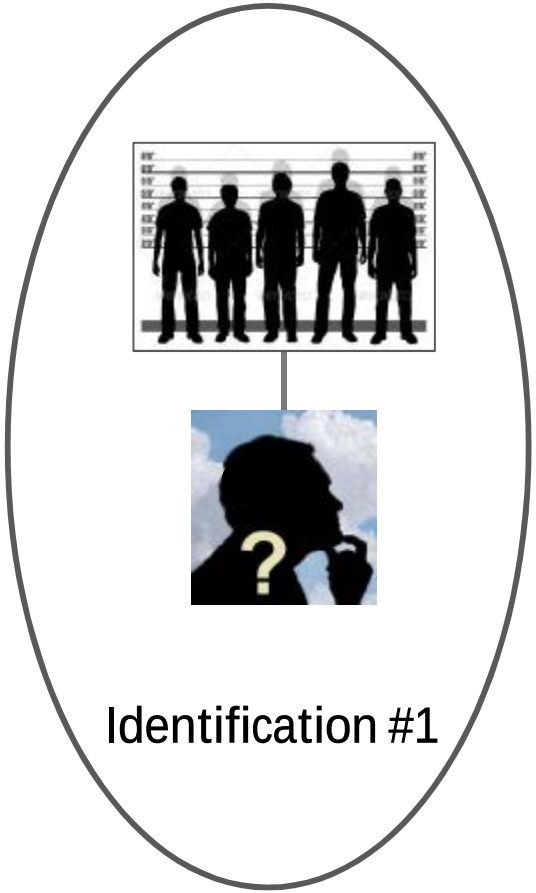
Identification #2

The relationship between eyewitness confidence and accuracy



"Most scientific studies have found the [confidence-accuracy] CA relationship to be relatively weak or nonexistent; in fact, this is one of the most consistent findings in the memory research literature…" (Krug, 2007, *Applied Psychology in Criminal Justice*, p. 31).

The relationship between eyewitness confidence and accuracy



"In the courtroom, too, juries find confident witnesses more persuasive…this despite the fact that witnesses' confidence, like that of the pundits, is largely uncorrelated with accuracy." (Don Moore, last Tuesday, *New Yorker*).

Journal of Experimental Psychology: Applied
2013, Vol. 19, No. 1, 55–71

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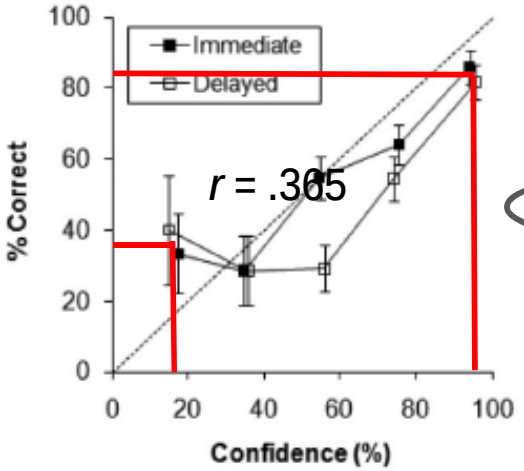
1076-898X/13/$12.00 DOI: 10.1037/a0031602

The Confidence-Accuracy Relationship for Eyewitness Identification Decisions: Effects of Exposure Duration, Retention Interval, and Divided Attention

Matthew A. Palmer, Neil Brewer, Nathan Weber, and Ambika Nagesh
Flinders University

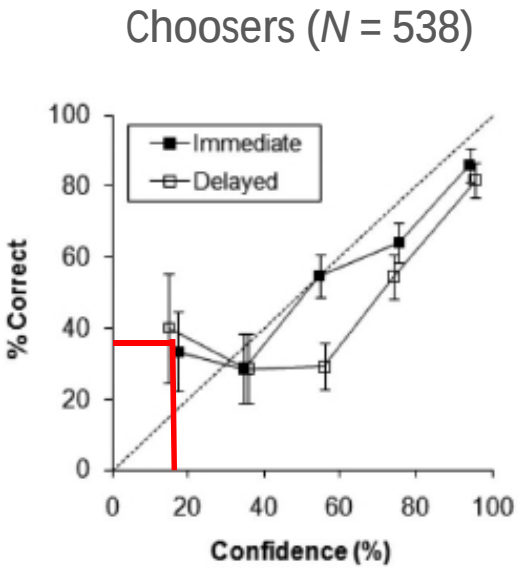
Choosers (*N* = 538)



"confidence…is largely uncorrelated with accuracy"

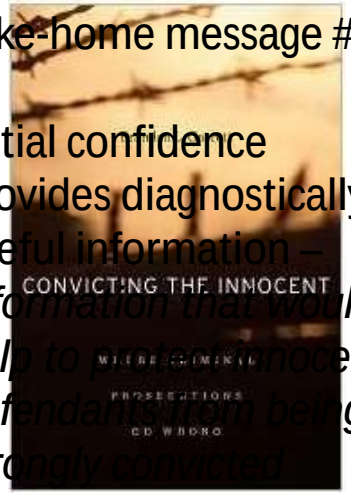
"…in 57% of these trial transcripts (92 of 161 cases), the witnesses reported they had *not* been certain at the time of their earlier identifications" (p. 49)

Ronald Cotton



Take-home message #2:

Initial confidence provides diagnostically useful information – *information that would help to protect innocent defendants from being wrongly convicted*



Identification #1: appeared very uncertain

Identification #2: absolute certainty

Conclusions

- Efforts to reduce the false ID rate often create a tradeoff, reducing the false ID rate by increasing the miss rate (Clark, 2012). Under those conditions, ROC analysis is the only way to determine the diagnostically more accurate procedure.

- Both theoretical and empirical considerations indicate that the emphasis should be placed on the diagnostic utility of initial confidence (not later confidence). The majority of DNA exonerees may never have been convicted in the first place had that simple fact been understood by jurors (Garrett, 2011).