

# FALSE ALARM

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## FALSE ALARM

**Primary Disciplinary Field(s):** Cognitive Psychology, Experimental Psychology, Statistics, Signal Detection Theory (SDT)

### 1. Core Definition

The **False Alarm** is a foundational metric within Signal Detection Theory (SDT), a mathematical framework developed to model how observers make decisions under conditions of uncertainty. Fundamentally, a False Alarm is defined as an incorrect observation or judgment where a participant reports the presence of a target stimulus during a trial when the stimulus was, in fact, **absent**--only noise or background activity was presented. This outcome represents a critical error of commission, signifying a failure to accurately discriminate the signal from baseline noise.

In the standard experimental paradigm, such as visual or auditory detection tasks, trials are typically divided into two categories: signal trials (where the stimulus is present) and noise trials (where the stimulus is absent). The False Alarm specifically occurs exclusively during the noise trials. The rate of False Alarms ( $P(FA)$ ) is calculated by dividing the total number of times the participant claimed to detect a signal by the total number of noise trials presented. This rate is indispensable because it helps researchers quantify the observer's decision threshold, or criterion, which is separate from their actual sensory ability or sensitivity.

### 2. Context in Signal Detection Theory

SDT utilizes a 2x2 matrix of outcomes to analyze performance: Hits and Misses (when the signal is present) and False Alarms and Correct Rejections (when the signal is absent). The False Alarm is conceptually vital as it helps anchor the noise distribution curve against which the signal distribution is compared. A high False Alarm rate implies that the observer has adopted a liberal response criterion, meaning they require very little evidence to confirm the presence of a signal, leading to many incorrect positive responses. Conversely, a low False Alarm rate suggests a conservative criterion, minimizing errors of commission but often increasing errors of omission (Misses).

The False Alarm holds a strong statistical analogy to the **Type I Error** in null hypothesis significance testing (NHST). In NHST, a Type I Error is the erroneous rejection of a true null hypothesis. In the context of signal detection, the null hypothesis corresponds to the state of "signal absent" (the noise trial). A False Alarm occurs when the observer incorrectly rejects this null state by responding "Yes, signal present." This correspondence highlights that the False Alarm represents a fundamental breakdown in reliable discrimination, serving as a key indicator of bias in decision-making processes across experimental and real-world applications.

### 3. Determinants of False Alarm Rates

The rate at which False Alarms occur is fundamentally driven by the interaction between inherent noise in the system and the observer's chosen **decision criterion**. The decision criterion is the internal threshold set by the participant, often influenced by external factors such as instructions, payoff matrices, and perceived consequences. If an experiment rewards Hits highly and ignores False Alarms, participants are incentivized to adopt a liberal criterion, thereby increasing their False Alarm rate. This relationship demonstrates that False Alarms are not merely random errors, but measurable outcomes reflecting a strategic bias in the allocation of attention and response.

While a majority of False Alarms are attributed to the psychological variables affecting the human observer--such as fatigue, expectation bias, or lapses in concentration, often termed **human error**--the initial source content acknowledges that systemic causes cannot be discounted entirely. In complex research setups, False Alarms can occasionally be traced back to **computer errors**, sensor malfunction, or transient environmental noise that mimics the signal. Rigorous experimental control is necessary to isolate and account for these technical sources of error, ensuring that the measured False Alarm rate accurately reflects the participant's perceptual and cognitive processing rather than equipment failure.

### 4. Measurement and Analytical Significance

Precise measurement of the False Alarm rate is mathematically necessary for calculating  $d'$  (d-prime), the primary measure of sensitivity in SDT, which assesses the distance between the mean of the noise distribution and the mean of the signal distribution. To calculate  $d'$ , the False Alarm probability,  $P(\text{FA})$ , must first be converted into a corresponding Z-score,  $Z_{\{\text{FA}\}}$ , derived from the standard normal cumulative distribution function. This Z-score indicates how far the observer's decision criterion lies from the average level of noise.

The sensitivity index is calculated as  $d' = Z_{\{\text{Hit}\}} - Z_{\{\text{FA}\}}$ . If the False Alarm rate is high (meaning the criterion is liberal and  $Z_{\{\text{FA}\}}$  is a smaller negative number, or even positive), it reduces the overall magnitude of  $d'$ , indicating low sensitivity or poor discrimination ability. If the False Alarm rate is zero, conventional SDT methods often employ a correction factor (e.g., adding 0.5 to both the number of False Alarms and the number of noise trials) to allow for the calculation of an interpretable Z-score, preventing undefined division and ensuring that highly conservative responses can still be analyzed within the framework.

### 5. Practical Applications and Costs

The concept of the False Alarm, often referred to as a "false positive" in non-academic contexts, carries significant weight in applications where decision-making involves critical consequences. In

**medical screening**, a False Alarm occurs when a healthy patient is incorrectly identified as having a condition, leading to substantial emotional distress, expensive follow-up testing, and sometimes invasive procedures that carry their own inherent risks. Minimizing the False Alarm rate is a constant trade-off against maximizing the Hit rate (detecting actual cases), requiring statistical models to optimize diagnostic thresholds based on the relative costs of each type of error.

In technology and safety systems, such as fire detection, automated quality control, or surveillance, a high rate of False Alarms can severely undermine the effectiveness and credibility of the system. Excessive False Alarms lead to **alarm fatigue**, where operators become desensitized to alerts, increasing the risk of missing a genuine signal (a Miss) when it finally occurs. Consequently, engineers and policy-makers must select operational criteria that maintain high vigilance while ensuring the False Alarm rate is low enough to prevent resource depletion and maintain operator trust, underscoring the broad societal impact of this fundamental psychophysical concept.

## 6. Key Characteristics

A **False Alarm** is defined as an incorrect positive response in the absence of the target signal, occurring exclusively during noise trials.

It is an error of commission and serves as the SDT counterpart to the **Type I Error** in traditional hypothesis testing.

The rate of False Alarms is the primary metric used to quantify the observer's decision bias or response criterion.

A high  $P(\text{FA})$  indicates a **liberal bias**, where the observer is quick to respond positively, resulting in a low internal threshold for detection.

The calculated  $Z_{\text{FA}}$  value is subtracted from  $Z_{\text{Hit}}$  to derive  $d'$ , the measure of sensory sensitivity, making the False Alarm rate crucial for separating sensitivity from response bias.

## 7. Further Reading

[Signal Detection Theory - Wikipedia](#)

[False Positive - Wikipedia](#)

[Psychology Dictionary: False Alarm](#)