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Models of lineup memory☆

John T. Wixted[a,*], Edward Vul[a], Laura Mickes[b], Brent M. Wilson[a]

[a] Department of Psychology, University of California, San Diego, United States
[b] Department of Psychology, Royal Holloway, University of London, United Kingdom

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A B S T R A C T

Face recognition memory is often tested by the police using a photo lineup, which consists of one suspect, who is either innocent or guilty, and five or more physically similar fillers, all of whom are known to be innocent. For many years, lineups were investigated in lab studies without guidance from standard models of recognition memory. More recently, signal detection theory has been used to conceptualize lineup memory and to motivate receiver operating characteristic (ROC) analysis of lineup performance. Here, we describe three competing signal-detection models of lineup memory, derive their likelihood functions, and fit them to empirical ROC data. We also introduce the notion that memory signals generated by the faces in a lineup are likely to be correlated because, by design, those faces share features. The models we investigate differ in their predictions about the effect that correlated memory signals should have on the ability to discriminate innocent from guilty suspects. A popular compound signal detection model known as the Integration model predicts that correlated memory signals should impair discriminability. Empirically, this model performed so poorly that, going forward, it should probably be abandoned. The best-fitting model incorporates a principle known as "ensemble coding," which predicts that correlated memory signals should enhance discriminability. The ensemble model aligns with a previously proposed theory of eyewitness identification according to which the simultaneous presentation of faces in a lineup enhances discriminability compared to when faces are presented in isolation because it permits eyewitnesses to detect and discount non-diagnostic facial features.

1. Introduction

Eyewitness misidentifications have contributed to a large number of wrongful convictions, and laboratory-based research designed to reduce that problem has focused largely on the format of lineups that the police use during the early stages of a criminal investigation (e.g., Lindsay & Wells, 1985). For many years, the relevant data were analyzed without any reference to the conceptual and analytical tools that are commonly used by cognitive psychologists to study recognition memory, but more recent research differs in that it has relied on signal detection theory to conceptualize and analyze receiver operating characteristic (ROC) data. However, thus far, competing signal detection models of eyewitness identification have not been formally specified and then tested for their ability to accurately characterize empirical data. The purpose of this article is to do just that.

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* Corresponding author.
E-mail address: jwixted@ucsd.edu (J.T. Wixted).

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Although live lineups were once the norm, nowadays ~90% of lineups administered by the police in the U.S. are photo lineups (Police Executive Research Forum, 2013). Like a live lineup, a photo lineup consists of one suspect, who is either innocent or guilty, and several (usually five) physically similar fillers, all of whom are known to be innocent. Typically, the photos are presented simultaneously to the witness, who can (1) identify the suspect (suspect ID), (2) identify a filler (filler ID), or (3) reject the lineup (no ID). Alternatively, the photos can be presented sequentially, with the procedure terminating when the first positive ID is made (Lindsay & Wells, 1985). Here, we focus on theories of recognition memory tested using the simultaneous photo-lineup procedure.

The lineup task is similar to a list-memory recognition task in many ways, but an important difference is that in a list-memory design, many different items are tested with one participant. By contrast, in a common lineup design, many different participants are tested with one set of items. Thus, instead of different items contributing to the variance of the distribution of memory signals across trials, different participants do. Either way, one distribution of memory signals is generated by previously seen targets, and the other is generated by novel lures. In an eyewitness identification experiment, the targets are guilty suspects, and the lures are innocent suspects and fillers. Achieving a greater theoretical understanding of those two memory-strength distributions is the goal of this article, and we do so by testing the ability of three specific signal-detection-based models of lineup memory to quantitatively characterize empirical ROC data.

2. Background theoretical considerations

Before delving into modeling details, we consider several preliminary theoretical and empirical issues. First, we describe how lineup memory is generally conceptualized within a signal detection framework and how each of the three signal detection models we later consider is defined by its unique diagnostic memory-strength variable. We then briefly survey prior research on the diagnostic variable that participants appear to rely upon when memory is tested using a collection of test items. Lastly in this section, we introduce the key notion of correlated memory signals in lineups, the predicted effect of which differs depending on which model is correct.

2.1. Modeling lineup memory using signal detection theory

The simplest signal detection model for simultaneous lineups was briefly mentioned by Macmillan and Creelman (1991, p. 251) in their classic signal-detection text and was considered in more detail by Duncan (2006) in a technical report. They both referred to this model as the Independent Observations model, as we will. According to this simple model, which we illustrate here in Fig. 1, memory strength values for lures (innocent suspects and fillers) and for targets (guilty suspects) are distributed according to Gaussian distributions with means of μ_{Lure} and μ_{Target}, and standard deviations of σ_{Lure} and σ_{Target}, respectively. The innocent suspect is, from the

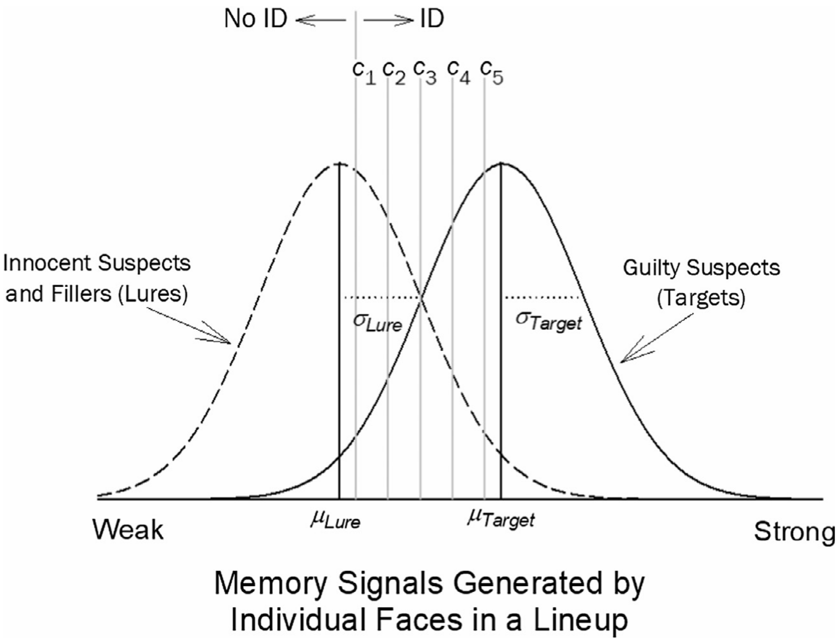

Fig. 1. Equal-variance Gaussian signal detection model for lineups. An ID is made if the memory-match signal of the most familiar (MAX) face in the lineup exceeds c_1. In that case, the confidence rating associated with the ID depends on the highest confidence criterion that is exceeded (e.g., the confidence rating is 5 if the strength of the MAX face exceeds c_5). Note that this model corresponds to a fair lineup. In an unfair lineup, the suspect stands out from the other fillers in such a way that the innocent suspect in a target-absent lineup more closely resembles the perpetrator than any of the fillers do. In that case, the innocent suspect and filler distributions would not have the same mean.