## Joint Models of Item and Source Memory in Two-Choice Tasks

To this point, we have considered recognition and source judgements separately, however, performance on item recognition and source memory tasks are commonly studied in tandem, which allows for a more comprehensive view of episodic memory than either type of judgement in isolation. A typical source-monitoring experiment sees subjects study items that are associated with one of two sources, A and B, and then are tested on a mixture of A items, B items, and new items that were not studied, N (Batchelder & Riefer, 1990). This paradigm allows for measurement of both the ability to discriminate between studied items and unstudied distractors and the ability to discriminate between source attributes of studied items. This comprehensive approach is particularly important if we assume that in doing either task, subjects build a mental representation, aspects of which are used to support both item and source judgements (Hautus et al., 2008). A major goal of the memory literature was to develop models that provide a joint account of recognition and source judgements. In this section, I introduce three classes of models: discrete-state, continuous, and dual-process models, followed by a review of the data from two-choice tasks these models were tested against, and finally argue that a more diagnostic paradigm in the continuous-outcome task is required to differentiate between these accounts.

### Threshold Models

The earliest approach to relating item recognition and source judgements with a mathematical model, taken by Batchelder and Riefer (1990), was to place the two in a processing-tree structure, with binary outcomes at each stage. This structure proposes that when retrieving information about the item in memory, a decision is first made about whether it was previously seen (in SDT terms, the detectability of the signal of an item from noise), and then if the item is deemed to have been studied, a subsequent decision is made about its source. The processing tree terminates in one of several possible outcomes and is described as multinomial because it models the probability of each of these outcomes occurring. Multinomial models are based on threshold theories of signal detection, which assume that the decision space can be divided into a number of discrete areas which describe different cognitive states subjects are in when they make a response (Krantz, 1969; Luce, 1963a; Luce, 1963b). A key goal of multinomial models of source memory is to separately measure source sensitivity and response bias, two measures that previously difficult to isolate empirically (Batchelder & Riefer, 1990; Batchelder et al., 1994). Although the intent of Batchelder and Riefer (1990) in introducing multinomial models of the source monitoring paradigm was to provide these separate measurements, the discrete branching paths of the processing tree can also be interpreted as a model of the process underlying recognition and source responding, namely that responses are generated as a result of a sequence of discrete states.

In the Batchelder and Riefer (1990) multinomial model, the first stage that determines if items, from either source, are detected (i.e. recognised as previously studied). In the item recognition judgement, the decision space is partitioned by a single threshold into two states with probability *D* and 1-*D*. This framework known as the *high-threshold* view of signal detection, which means that on lure trials where there is no memory signal (when the item is actually new), “old” responses are only generated as a result of a guess with probability *b* and lures are otherwise correctly identify the item as new. In other words, a nonsignal never exceeds the detection threshold, which lends the high-threshold theory its name. Because there is only a single threshold partitioning the space, the recognition component of the Batchelder and Riefer (1990) model can be referred to as a one high-threshold (1HT) model, which distinguishes it from the source judgement which is assumed to be a two-high threshold (2HT) process. The two thresholds in the source judgement divide the decision space into three areas, so that if one threshold is crossed the source is identified as A, if the other threshold is also crossed the source is identified as B, while if neither threshold is crossed then no information is available and source A is guessed with probability *a*, and source B is guessed with probability 1-*a*.

Diagram

Description automatically generated

Historically, 1HT models have been criticised for making predictions about the shape of the receiver-operating characteristic (ROC; discussed in detail later) that are contrary to sensory and recognition memory data, which Kinchla (1994) argued renders the Batchelder and Riefer (1990) model inadequate as a model of source-monitoring (Green & Swets, 1966; Luce, 1963; Murdock, 1974). Notably, the adoption of a 1HT model of recognition is a specific feature of the Batchelder and Riefer (1990) model, and not of all multinomial models. Instead, multinomial models with a single low threshold (LT; Batchelder et al., 1994; Macmillan & Creelman 1991) and 2HT recognition processes (Bayen et al., 1996) have also been proposed, although the source judgement is consistently modelled as a 2HT process and so these multinomial models made the same predictions about the shape of source ROCs.

### Continuous Signal-Detection Models

Continuous models of source memory are based on Signal Detection Theory.

Continuous models of source memory extend SDT such that memory strength is assumed to vary continuously on two dimensions, bivariate SDT.

(Banks, 2000; Glanzer, Hilford, & Kim, 2004; Mickes et al., 2009).

In its application to the study of memory, SDT proposes that recognition judgements are based on its familiarity- which by analogy is a signal which varies in strength.

### Dual-Process Models

In a dual-process view (Yonelinas, 1999), one can respond by directly retrieve an item from memory through recollection, or by simply making a judgement about whether the item is memory or not without retrieving it, based on a feeling of familiarity. In this way, both recollection and familiarity can contribute to successful recognition. On the other hand, in a source memory task, familiarity cannot distinguish between two studied items from different sources, as both items are present in memory and should therefore be equally familiar. Thus, source judgements are thought to reflect a pure recollection process. When performing a recognition task, one can respond by directly retrieve an item from memory through recollection, or by simply making a judgement about whether the item is memory or not without retrieving it, based on a feeling of familiarity. In this way, both recollection and familiarity can contribute to successful recognition. On the other hand, in a source memory task, familiarity cannot distinguish between two studied items from different sources, as both items are present in memory and should therefore be equally familiar. Because source judgements rely only on recollection, the Yonelinas (1999) dual-process model predicts that source judgements should rely purely on a high threshold recollection process. Thus, dual-process and discrete-state models make identical predictions about source memory but are distinguishable on item recognition.

### ROC Predictions of Source Memory Models