



Optimization of a multinomial model for investigating hallucinations and delusions with source monitoring

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Abstract

Studies of source monitoring have played an important role in cognitive investigations of the inner/outer confusions that characterize hallucinations and delusions in schizophrenia, and multinomial modelling is a statistical/cognitive modelling technique that provides a powerful method for analyzing source monitoring data. The purpose of the current work is to describe how multinomial models can be optimized to answer direct questions about hallucinations and delusions in schizophrenia research. To demonstrate this, we present a reanalysis of previously published source monitoring data, comparing a group of patients with schneiderian first rank symptoms to a group without schneiderian first rank symptoms. The main findings of this analysis were (1) impaired recognition of self-generated items and (2) evidence that impaired source discrimination of perceived items is accompanied by an internalization bias in the target symptom group. Statistical and cognitive interpretations of the findings are discussed.

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Fundamental to an understanding of reality distortion in schizophrenia (i.e., hallucinations and delusions) is the study of inner/outer confusions in

cognition (Fowler, 2000). This relationship is most apparent when considering auditory hallucinations, as these can be conceptualized as the assignment of internally generated mental events to an external source. Originally referred to as reality monitoring (Johnson et al., 1993), the study of inner/outer confusions in memory has recently been employed to investigate the cognitive underpinnings of schizophrenia, typically under the rubric of source monitor-

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ing (e.g., Brébion et al., 2000; Keefe et al., 2002; Moritz et al., 2003, 2005; Morrison and Haddock, 1997; Vinogradov et al., 1997).

One of the limitations of many of these studies is that guessing strategies (e.g., strategically increasing external-source guesses) have not been separated from memory errors; however, multinomial modelling allows these processes to be separately measured. Multinomial models attempt to explain discrete responses in a particular psychological paradigm by postulating latent cognitive processes that combine in different ways to determine the response category. The basic idea is that any given response category may occur as a consequence of one or more processing sequences, where each processing sequence is characterized by a series of successful or unsuccessful processing events. The processing sequences are represented in a tree structure (see Fig. 1). The root (or initial node) represents the beginning of the processing sequence, the intermediate nodes represent stages involving a choice between two or more processing events, and the terminal nodes correspond to the observable response categories. The application

of multinomial models to source monitoring has been reviewed in detail elsewhere (Batchelder and Riefer, 1999).

Multinomial modelling provides separate source misattribution parameters for when items are recognized and when items are not recognized; we refer to the former as *biases*, and the latter as *guesses*. It is the biases, which affect reactivated “in mind” cognitive representations (i.e., recognized items in the source monitoring memory context), that are of primary interest for the study of hallucinations and delusions (Keefe et al., 2002, p. 53). Multinomial models used in previous studies of schizophrenia (Keefe et al., 2002, 1999) were developed within the context of cognitive psychology, but were not optimized for the study of hallucinations and delusions. In traditional multinomial models, parameters are created for old and new recognition (parameter D in Fig. 1), source recognition (parameter d in Fig. 1) and biases. However, estimates of true internalization and externalization biases are not possible, because parameter estimates *do not vary with the originating source*. That is to say, unlike the recognition (parameters D_{1-}

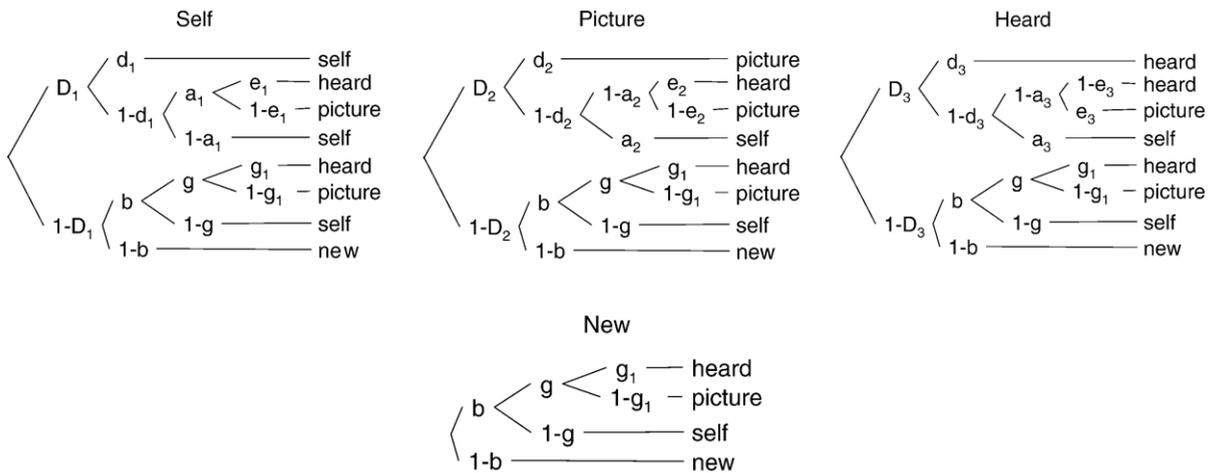


Fig. 1. Tree diagrams for the final three-source multinomial model, with separate trees for self-generated, picture, heard source items, and new items. D_1 =probability of recognizing self-generated items as old; D_2 =probability of recognizing picture items as old; D_3 =probability of recognizing heard items as old; d_1 =probability of discriminating the source of recognized self-generated items; d_2 =probability of discriminating the source of recognized picture items; d_3 =probability of discriminating the source of recognized heard items; a_1 =probability of externalization when self-generated items are recognized but not discriminated; a_2 =probability of internalization when picture items are recognized but not discriminated; a_3 =probability of internalization when heard items are recognized but not discriminated; e_1 =probability of attributing a self-generated item to the heard source if an externalization is made; e_2 =probability of confusing the two external sources for picture items; e_3 =probability of confusing the two external sources for heard items.

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