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Assumptions behind scoring source versus item memory: Effects of age, hippocampal lesions and mild memory problems



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ABSTRACT

Source monitoring paradigms have been used to separate: 1) the probability of recognising an item (Item memory) and 2) the probability of remembering the context in which that item was previously encountered (Source memory), conditional on it being recognised. Multinomial Processing Tree (MPT) models are an effective way to estimate these conditional probabilities. Moreover, MPTs make explicit the assumptions behind different ways to parameterise Item and Source memory. Using data from six independent groups across two different paradigms, we show that one would draw different conclusions about the effects of age, age-related memory problems and hippocampal lesions on Item and Source memory, depending on the use of: 1) standard accuracy calculation vs MPT analysis, and 2) two different MPT models. The MPT results were more consistent than standard accuracy calculations, and furnished additional parameters that can be interpreted in terms of, for example, false recollection or missed encoding. Moreover, a new MPT structure that allowed for separate memory representations (one for item information and one for item-plus-source information; the Source-Item model) fit the data better, and provided a different pattern of significant differences in parameters, than the more conventional MPT structure in which source information is a subset of item information (the Item-Source model). Nonetheless, there is no theory-neutral way of scoring data, and thus proper examination of the assumptions underlying the scoring of source monitoring paradigms is necessary before theoretical conclusions can be drawn.

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Abbreviations: MMP, mild memory problems group; HL, Hippocampal Lesion group; MPT, Multinomial Processing Tree; S1, Source 1; S2, Source 2; Ds, probability of remembering source; Di, probability of remembering item; Gs, probability of guessing item's source as S1; Gi, probability of guessing an item is old; Db, probability of retrieving information about source and item; Dn, probability of rejecting an unstudied item; Dh, probability of veridical recollection; Df, probability of false recollection; Dm, probability of missed encoding; 1HT/2HT, one- or two-High-Threshold; LT, low threshold; SDT, Signal-Detection Theory; AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion.

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1. Introduction

Evidence from source monitoring paradigms has been influential in shaping theories of human memory (e.g., Johnson, Hashtroudi, & Lindsay, 1993; Mitchell & Johnson, 2000, 2009; Slotnick & Dodson, 2005; Yonelinas, 1999). These paradigms present participants with an item (e.g., object or word), and ask them to decide whether they studied it previously, and if so, to distinguish in which of two or more sources it was studied (e.g., spatial location or temporal sequence). Comparisons of several populations, such as young versus older (e.g., Cohen & Faulkner, 1989; McIntyre & Craik, 1987; Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991; Schacter, Osowiecki, Kaszniak, Kihlstrom, & Valdiserri, 1994; Spencer & Raz, 1995), or healthy controls versus amnesic patients (e.g., Schacter, Harblul, & McLachlan, 1984; Shimamura & Squire, 1987), have often revealed a dissociation, whereby memory for the source differs between groups, even when memory for the item does not. This has been used to support theories that assume separate processes or systems supporting Item and Source memory (Shimamura & Squire, 1987; Yonelinas, 1999), though the precise pattern of dissociations depends on other factors such as the nature of the source (e.g., Cohen & Faulkner, 1989; Dodson, Bawa, & Slotnick, 2007; Hashtroudi, Johnson, & Chrosniak, 1989; Johnson et al., 1993; McIntyre & Craik, 1987; Simons, Dodson, Bell, & Schacter, 2004).

In the context of ageing, a related idea is the associative memory hypothesis of Naveh-Benjamin (2000), which proposes that memory problems in older individuals stem from difficulties in associating distinct pieces of information. This theory subsumes source memory, since the age-related source memory deficits that occur under many circumstances are interpreted as the failure to link an item with its source (Bender, Naveh-Benjamin, & Raz, 2010; Chalfonte & Johnson, 1996; Naveh-Benjamin, 2000; Naveh-Benjamin, Brav, & Levy, 2007; Naveh-Benjamin, Guez, Kilb, & Reedy, 2004). Nonetheless, under some circumstances, such as when older participants are explicitly instructed to use a linking strategy, age-related impairments in associative memory can be ameliorated (Bastin et al., 2014; Naveh-Benjamin et al., 2007).

In the context of patients with brain disorders, individuals with amnesia following medial temporal lobe damage to structures like the hippocampus can sometimes show item memory deficits, but often show disproportionate deficits in source memory (Schacter et al., 1984; Shimamura & Squire, 1987; Yonelinas et al., 2004). Moreover, individuals with frontal lobe damage consistently show source memory deficits with minimal or no item memory deficits, producing a dissociation often more extreme than amnesic patients without frontal lobe lesions (Duarte, Henson, Knight, Emery, & Graham, 2010; Janowsky, Shimamura, & Squire, 1989; Schacter, 1987).

Despite these general patterns, there are, as alluded to above, other important factors that affect the relative size of the deficits in source versus item memory performance (e.g., deficits in source memory only, source memory impaired more than item memory, or both impaired equally), such as type of encoding or retrieval strategy, or the type of stimulus (for review, see Old & Naveh-Benjamin, 2008; Spencer & Raz,

1995). However, a further factor that affects results, but which is often over-looked, is the method of scoring source versus item memory.

1.1. Scoring source memory

A typical source monitoring paradigm involves categorising test items into one of three categories: unstudied (New), studied in Source 1 (S1) and studied in Source 2 (S2). Item memory is often estimated by the proportion of studied items called S1 or S2 (Item Hits), perhaps adjusted for guessing by subtracting the proportion of unstudied items called S1 or S2 (Item False Alarms). Source memory is then typically measured by estimating the probability of categorising the source correctly, given that a studied item was recognised (not called New), i.e., the conditional probability of a Source Hit given an Item Hit (Chalfonte & Johnson, 1996; McIntyre & Craik, 1987; Murnane & Bayen, 1996; Siedlecki, Salthouse, & Berish, 2005; Tree & Perfect, 2004). However, as pointed out by several authors (e.g., Batchelder & Riefer, 1990), these conditional estimates of source memory are still influenced by overall recognition performance and by guessing rates. Moreover, markedly different numbers of trials (e.g., Item Hits) per participant can impair estimation of the average conditional probability across participants (Cox & Snell, 1989). Most importantly, however, the assumptions underlying this standard scoring method are rarely made explicit. For example, Item memory and Source memory could be ordered along a single dimension of memory quality, capturing uni-dimensional theories of memory (see below). One way to formalise assumptions behind the scoring of source monitoring paradigms is to use Multinomial Processing Trees (MPTs) (Batchelder & Riefer, 1990).

There is a long pedigree of research using MPTs, which can be applied to many psychological domains (see Erdfelder et al., 2009, for a review). For example, the one- or two-High-Threshold (1HT/2HT) models of yes/no recognition memory (which can be seen as a special case of source monitoring with only one source), as reviewed by Snodgrass and Corwin (1988), correspond to different MPTs, and these threshold models have since been extended to the more general case of source monitoring (Bayen, Murmane, & Erdfelder, 1996). Similarly, the “process dissociation procedure” developed by Jacoby (1991) is naturally expressed in terms of a MPT, and has been extended by Erdfelder et al. (2009). More generally, there has been much debate about whether performance on such memory tests is best modelled by continuous distributions of memory strength, as assumed by Signal-Detection Theory (SDT), rather than the discrete memory states assumed by MPTs (Klauer & Kellen, 2010). While continuous levels of item memory and even source memory seem more plausible *a priori*, discrete state models have been shown to offer superior fits over continuous (e.g., SDT) models, when using a Minimum Description Length (MDL) index of fit that takes into account differences in the functional forms of the models (in terms of their flexibility; Kellen, Klauer, & Bröder, 2013). In this statistical sense, discrete state models like MPTs may be preferable for comparing estimates across groups, particularly for binary item and source judgements, as is the case in typical source monitoring tasks.

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