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Modeling source-memory overdistribution

David Kellen *, Henrik Singmann, Karl Christoph Klauer

Institut für Psychologie, Albert-Ludwigs-Universität Freiburg, D-79085 Freiburg, Germany

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ABSTRACT

In a process-dissociation task of source memory, individuals have to judge whether items belong to one of different, mutually exclusive contexts (e.g., Source A, Source B). The acceptance rates to different test probes (e.g., "Source A?") can be used to estimate the probability that the item is assigned simultaneously to the different contexts ("Source A *and* Source B"), designated as *source overdistribution*. Brainerd et al. (2012) have argued that source overdistribution can be used to refute traditional models of source memory such as the One or Two High-Threshold Source-Memory models (1HTSM and 2HTSM; Batchelder and Riefer, 1990; Bayen et al., 1996). We reanalyze previously-published datasets, including Brainerd et al.'s data, and show that there is no support for the rejection of the 1HTSM/2HTSM. Moreover, through a hierarchical-Bayesian model comparison using data from two new experiments, we show that the 2HTSM is not only able to account for source overdistribution, but also provides the best account of the data among different candidate models. These new results suggest that source overdistribution is an outcome of different guessing processes.

Introduction

An important distinction in the memory literature is between *item memory* and *source memory* (Johnson, Hashtroudi, & Lindsay, 1993). While item memory concerns the ability to remember previously acquired information (e.g., "Did I see this word before in the experiment?"), source memory is concerned with contextual details associated with the acquisition of information (e.g., "who said this word?"). The relationship between these two types of memory has produced a considerable body of work along with a diverse set of models (Batchelder & Riefer, 1990; Bayen, Murnane, & Erdfelder, 1996; Hautus, Macmillan, & Rotello, 2008; Klauer & Kellen, 2010; Meiser & Bröder, 2002; Onyper, Zhang, & Howard, 2010; Qin, Raye, Johnson, & Mitchell, 2001; Schütz & Bröder, 2011).

Despite some divergences in the literature, there is a considerable level of convergence regarding the relationship between item and source memory (Klauer & Kellen, 2010; Onyper et al., 2010). This understanding of item and source memory has recently been questioned by Brainerd, Reyna, Holliday, and Nakamura (2012), who reported a phenomenon entitled *source overdistribution* that they argued to be incompatible with current modeling approaches, such as the One and Two-High Threshold Source-Memory Models (1HTSM and 2HTSM; Batchelder & Riefer, 1990; Bayen et al., 1996).[1] In addition, Brainerd et al. (2012) proposed a new model that is able to overcome the reported shortcomings of the 1HTSM/2HTSM.

The manuscript is organized as follows: First, we will discuss the 1HTSM/2HTSM. This is followed by a characterization of source overdistribution and how it

* Corresponding author.
E-mail address: david.kellen@psychologie.uni-freiburg.de (D. Kellen).

[1] Throughout their manuscript, Brainerd et al. (2012) exclusively refer to the 1HTSM proposed by Batchelder and Riefer (1990). Still, the model equations presented include a distractor-detection parameter D_N belonging to the 2HTSM, which was later introduced by Bayen et al. (1996). Because of this confusion we attempt to refer to both models (1HTSM/2HTSM) when discussing Brainerd et al.'s claims. We also refer to the two models when discussing aspects that hold for both of them.

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can be accounted for by the 1HTSM/2HTSM as well as by a new model proposed by Brainerd et al. (2012). We will show that Brainerd et al.'s dismissal of the 1HTSM/2HTSM as well as their characterization of memory processes made on the basis of their new model can be questioned on several grounds. Furthermore, we report results from a reanalysis of data from Brainerd et al. (2012), Brainerd, Wang, and Reyna (2013), and Yu and Bellezza (2000). Finally, we report two new experiments using an extended task in order to provide a better understanding of source overdistribution and its impact in memory modeling.

Modeling item and source memory data

The traditional method for evaluating source-memory consists of a study phase in which items with different contextual characteristics (i.e., different sources) such as words with different colors (e.g., red words and green words) are presented. Individuals subsequently engage in a test phase in which they have to distinguish between studied and non-studied words and identify the source of recognized items. There are typically two sources, A and B, and the response alternatives in this *source-memory task* are "Source A", "Source B", and "New".

The relationship between item and source-memory judgments is frequently modeled by means of measurement models designed to disentangle the contribution of different cognitive processes (Klauer & Kellen, 2010). One such model is the 2HTSM (Bayen et al., 1996), a model belonging to the Multinomial Processing Tree (MPT) model class (Batchelder & Riefer, 1999; Riefer & Batchelder, 1988). The 2HTSM assumes a finite set of discrete mental states that can be entered conditional on the occurrence of specific cognitive processes. The parameters in the model quantify the probability of each of these processes taking place (the parameter values are therefore bounded between 0 and 1). The 2HTSM is depicted in Fig. 1 for the case of two sources (A and B) in which the model assumes five mental states, from M_1 to M_5:

- M_1: An A item is remembered as previously studied and stemming from Source A.
- M_2: A B item is remembered as previously studied and stemming from Source B.
- M_3: An old item is remembered as previously studied, but memory for the source is absent.
- M_4: A new item is detected as new.
- M_5: An item presented at test is not remembered as previously studied nor is it detected as new.

The probability of each mental state being entered, given a particular type of item (A, B, or new), is determined by detection parameters that quantify the probability of specific memory processes successfully occurring: Parameters D_A and D_B correspond to the probability, respectively, of A and B items being remembered as previously studied (item memory). The memory-retrieval processes associated with D_A and D_B determine whether an item was previously studied or not, but not the source of these items. Parameter D_N captures the probability that a new item is actively rejected via so-called recall-to-reject processes (e.g., Rotello & Heit, 2000) or metacognitive strategies (e.g., Strack & Bless, 1994). In the restricted version of the 2HTSM, the 1HTSM, the possibility of an item being detected as new (M_4) is excluded (i.e., $D_N = 0$), so that responses to new items are completely governed by guessing processes, which will be described below.

Parameters d_A and d_B quantify the probability that the source of a studied item is remembered, conditional on item memory. The probability of the mental states described above being entered is a function of all of the above parameters: For example, for A items the probability of state M_1 corresponds to $D_A \times d_A$. From a broader perspective, the detection processes described by parameters D and d can be aligned with the familiarity and recollection processes postulated by dual-process models of memory (Klauer & Kellen, 2010; see also Malmberg, 2008).[2]

In states M_1, M_2, and M_4, the true status of the test item has been detected, which means that a correct response (responses "Source A", "Source B", and "New", respectively) is given with probability 1. In contrast, in M_3 and M_5 the true status of the test item is only partially detected or completely unknown, respectively. In these states, responses are guesses: State M_3 is mapped onto responses "Source A" and "Source B" with guessing probabilities γ_A and γ_B, with $\gamma_A + \gamma_B = 1$. In state M_5, responses "Source A", "Source B", and "New" are given with guessing probabilities β_A, β_B, and β_N, respectively, with $\beta_A + \beta_B + \beta_N = 1$. At this point, an important feature of the model should be emphasized: The detection processes modeled by parameters D_A, D_B, and D_N always provide accurate information, which means that the model does not permit judgment errors based on false information retrieved from memory. Consequently, the model attributes all observed errors to guessing processes, which are described by the γ and β parameters.[3] It is important to note that the exclusive assignment of errors to guessing processes does not mean that one is claiming that other types of errors (e.g., false recollection) do not exist. Rather that such types of errors do not constitute a major aspect of the particular data being characterized by the model (recognition memory judgments for non-related word lists associated to arbitrary contexts or sources). This is not expected to hold in the case of data coming from experimental paradigms where semantic/associative false memories are expected (for reviews, see Brainerd & Reyna, 2005; Gallo, 2006).

The model has been found to provide adequate fits to experimental data and has been experimentally validated:

[2] This comparison with dual-process models is done rather loosely and does not imply that the familiarity and recollection parameters in the dual-process model *exactly* correspond to item and source detection, respectively. As shown by Yu and Bellezza (2000, p. 1527), recollection and familiarity can be shown to be a complex function of item and source detection as well as guessing processes.

[3] This specification of the 1HTSM/2HTSM is actually a reparametrization of the one originally proposed by Batchelder and Riefer (1990), according to which there are two types of guessing judgments: (1) item-memory (old-new) judgments represented by parameter b, and (2) source-memory (Source A – Source B) guessing judgments represented by parameters a and g operating on mental states M_3 and M_5, respectively. The current model specification corresponds to Batchelder and Riefer's if $\gamma_A = a, \gamma_B = 1 - a$, $\beta_A = b \times g, \beta_B = b \times (1 - g)$, and $\beta_N = 1 - b$.