Journal of Mathematical Psychology 56 (2012) 35–53

Contents lists available at SciVerse ScienceDirect

Journal of Mathematical Psychology

journal homepage: www.elsevier.com/locate/jmp

Obtaining separate measures for implicit and explicit memory

Richard A. Chechile [a,*], Lara N. Sloboda [a], Jessica R. Chamberland [b]

[a] Tufts University, United States
[b] Unilever Research and Development, United States

ARTICLE INFO

Article history:
Received 19 July 2010
Received in revised form
12 January 2012
Available online 4 February 2012

Keywords:
Implicit memory model
Fractional storage
Multinomial modeling
Dual-process model
Process-dissociation model

ABSTRACT

In this paper a new model, the Implicit/Explicit Separation (IES) model, is developed and applied. The model is designed to obtain separate probability measures for explicit memory storage, implicit memory storage, fractional storage, and non-storage. The model is needed because memory research has shown the importance of the distinction between a conscious memory of a target event and a memory residue that is unable to support conscious recall or confident recognition, but it is still able to support guessing at rates above chance. Maximum likelihood and population-parameter mapping estimates for the parameters of the IES model are provided. The accuracy of parameter estimates is studied as a function of sample size. Three experiments are reported to demonstrate how the IES model is used to achieve a more fine grained assessment of the quality of information storage. These experiments also provide strong validation support for the IES model itself. Across the three experiments, each of the four components for representing target information (explicit, implicit, fractional, and non-storage) demonstrates a different pattern. The IES model is discussed in terms of alternative models such as the dual-process model and the process-dissociation model.

1. Introduction

An important distinction in contemporary memory research is that between explicit and implicit memory. Explicit memory is considered to be a memory associated with conscious awareness. Explicit memory is exemplified by the situation when a person accurately recalls what they ate for dinner last evening or when a person correctly recognizes a friend who has been away for several months. In contradistinction to explicit memory, implicit memory is considered as a residue from prior experience that is not capable of supporting conscious recall or confident correct recognition. The residue might be the remains of a memory trace that has undergone dramatic weakening. Although implicit memory is a weak residue, it is still capable of influencing above chance recognition guessing or is capable of producing priming.

The distinction between explicit and implicit memory emerged from early work in neuropsychology. For example, Warrington and Weiskrantz (1974) found that if amnesic patients read a word earlier, then later they would be more likely to complete an ambiguous word fragment with that word even though they reported being unable to remember seeing the word previously. Initially, memory researchers attempted to link implicit and explicit memory to specific tasks or dependent variables. The assumption was that certain tasks tapped only a single type of memory. This assumption or hypothesis is called the process purity approach. Roediger and McDermott (1993) and Schacter (1987) reviewed many experimental studies that were conducted under the assumption of the process purity approach. Here the memory researcher typically assumes that some available dependent variable taps only implicit memory while some other variable taps only explicit memory. Yet it is difficult to know, and unreasonable to assume, that there are cognitive tasks that influence only a single process. It is more likely that any specific dependent variable involves a mixture of underlying cognitive processes. Multinomial processing tree modeling (MPT) is ideally suited for disentangling the latent cognitive processes that are involved in experimental tasks. Batchelder and Riefer (1999) and Erdfelder et al. (2009) provide excellent reviews of many of the MPT models in psychology. Unlike the process purity approach, MPT models are tree models of the underlying psychological processes that are involved in a specific task. In some cases, novel experimental procedures are used by the MPT modeler in order to obtain the information needed to estimate the latent psychological processes of interest. In essence the MPT model makes clear how the latent cognitive processes map onto the available dependent variables without assuming the existence of a simple one-to-one mapping between a dependent variable and a latent process. In fact, Chechile (2007) and Chechile and Roder (1998) have argued that a mathematical model is generally required in order

* Correspondence to: Psychology Department, Tufts University, Medford, MA 02155, United States.
E-mail address: Richard.Chechile@Tufts.edu (R.A. Chechile).

0022-2496/$ – see front matter © 2012 Elsevier Inc. All rights reserved.
doi:10.1016/j.jmp.2012.01.002

to measure underlying cognitive processes because dependent variables from experiments do not reflect the influence of only one psychological process.

Jacoby (1991) invented an experimental task and a model that ostensibly provided a means for obtaining separate measures for explicit and implicit memory. An improved extension of the Jacoby (1991) model was advanced by Buchner, Erdfelder, and Vaterrodt-Plünnecke (1995). These models and the experimental task on which they are based have come to be called the process-dissociation method. The process-dissociation procedure relies on an instructional manipulation. In a typical process-dissociation task, the participants receive memory training on two sources of information, such as a first and a second list. Later the participants are given either inclusion instructions or exclusion instructions. The inclusion instruction directs the subject to respond yes to a test item if the item matches any of the items from either list; whereas the exclusion instruction directs the subjects to only use the yes response for test items believed to be from the second list. In the Jacoby (1991) model the parameter c denotes the conscious memory probability and the unconscious familiarity parameter is the u parameter. Jacoby (1991) argued that under the exclusion instruction the proportion of yes responses to second list words should only result if there was an absence of a conscious (explicit) memory but there was still a sense of familiarity associated with the words, i.e. $P(yes|exclusion) = (1 - c)\,u$. However, in the inclusion instructional condition, the subject would respond yes with either a conscious memory of the second list word or because the word had an unconscious familiarity, so $P(yes|inclusion) = c + (1 - c)\,u$. Thus in the Jacoby model the conscious component was estimated as simply $P(yes|inclusion) - P(yes|exclusion)$. The Buchner et al. (1995) model included a guessing correction based on some additional test trials with novel items or foils. The process-dissociation models have been widely used in cognitive psychology (e.g. Buchner et al., 1995, Jacoby, Toth, & Yonelinas, 1993, McBride & Dosher, 1999, and McBride, Dosher, & Gage, 2001) as well as in social psychology (e.g. Buchner & Wippich, 1996, and Gaunt, Leynes, & Demoulin, 2002).

Although it is advantageous to use a cognitive psychometric approach for measuring explicit and implicit memory, there are many problems with the process-dissociation procedure (Dodson & Johnson, 1996; Yu & Bellezza, 2000). Rather than retracing the criticisms of Dodson and Johnson (1996) and Yu and Bellezza (2000), we will instead focus on some additional concerns with the process-dissociation procedure that motivated the development of an improved method for separately measuring explicit and implicit memory. First, it is noteworthy that the process-dissociation model has a limitation of being a saturated model on an individual condition basis. Although it is possible to use saturated models, it is also advantageous to have a model that can provide a strong test of the model's suitability in each experimental condition. The process-dissociation model is limited in this regard.[1] A second concern is a more serious problem, and it is related to the fact that the process-dissociation model does not provide a correction for the influence of a conscious recollection of partial information. A conscious memory fragment would help if the subject had the inclusion instruction, but it would be less helpful under the exclusion instruction. For example, if a person remembers an item but does not remember the list on which it was presented, then that explicitly conscious partial information would result in a yes response when tested with the inclusion instruction, but it is less likely to result in a yes response with the exclusion instruction. Because the process-dissociation model identifies the c parameter as the difference between the yes response rate in the inclusion instructional condition with the yes rate in the exclusion condition, fractional storage would tend to be measured as a part of explicit memory. The effect of partial information would also bias the rate for implicit memory.[2] There is also a third problem with the process-dissociation procedure related to the possibility that the instructions themselves might cause a criterion shift in a signal-detection sense. For example, given a level for familiarity strength, there could be a difference in the criterion for responding yes in the two instructional conditions. In the process-dissociation model, it is assumed that the familiarity process has the same tendency to result in an affirmative response regardless of the instructional condition. But, at a fixed familiarity level, a shift in the criterion to respond yes, caused by the instructional manipulation, would alter and contaminate the estimates of explicit and implicit memory.[3]

Given these difficulties with the process-dissociation procedure, it is advantageous to develop a new model for measuring implicit memory that is: (1) not a saturated model, (2) a model that deals with fractional information storage, and (3) a model that does not rely upon an instructional manipulation. In this paper a new model is advanced for obtaining separate measures of explicit and implicit memory. The model is called the Implicit/Explicit Separation (IES) model. The model is based on a specific experimental task. The framework for the task is developed in Section 2. A description of the model and parameter estimates are provided in respectively, Sections 3 and 4. In Section 5 Monte Carlo sample studies are described for studying the accuracy of the estimates as a function of sample size. In Section 6 three experiments are provided that demonstrate how the new model can be used to examine a number of important effects in memory research. Experiment 1 addresses the effect of encoding time; whereas Experiment 2 deals with the effect of generative encoding, and Experiment 3 examines the effect of retention interval. Finally in Section 7, there is a general discussion of the IES model in light of the experimental findings and a comparison to other models for memory.

1 Some saturated models can be evaluated in each condition by using the population-parameter mapping (PPM) estimation method (Chechile, 1998, 2004, 2009, 2010a,b). For example, with the PPM method there is a measure of model coherence, $P(coh)$. If a model has a low $P(coh)$ value in the absence of data and has a high $P(coh)$ value after the data are collected, then the data have increased the evidence in favor of the model. However, if the prior value of $P(coh)$ is large, then it is difficult to show with the $P(coh)$ measure increased support for the model from any experiment regardless of the sample size. The Jacoby process-dissociation model has the prior $P(coh) = 0.5$. This result occurs because of a requirement that c must be positive. If c is negative, which can happen stochastically with the PPM procedure, then that is an incoherent sample. See the Appendix for more detail about the PPM procedure. The posterior-to-prior odds ratio for $P(coh)$ is denoted as $\omega(coh)$. For the Jacoby (1991) model $\omega(coh) \leq 2$. Hence, there is a low limit to the evidence ratio that can be obtained for this model regardless of sample size. The criticism here is not against the use of saturated models, but the criticism is directed towards the subset of saturated models where $\omega(coh)$ is limited to small values.

2 For example, in the Jacoby (1991) model, the implicit memory estimate is $\frac{hits(E)}{hits(E)+1-hits(I)}$, so an increase in only the hit rate with inclusion instructions caused by fractional information would increase the estimated value for implicit memory. Although the extended process-dissociation model by Buchner et al. (1995) has a different equation for estimating the implicit component because there are corrections for guessing, this model would nonetheless also have an increased value for implicit memory if there were a contribution due to fractional storage.

3 This concern about a criterial shift caused by the instructions is supported in fact by the response rates for foil trials in the Buchner et al. (1995) study. Across the three experiments reported in that paper, the proportions for a yes response on foil trials with inclusion and exclusion instructions are respectively 0.278 and 0.075. Presumedly foils have the same familiarity under the two instructions, but there is nonetheless a large change in the tendency to respond in the affirmative. Both the Jacoby (1991) model and the Buchner et al. (1995) extended model assume that the explicit component and the implicit component have values that are the same in the inclusion and exclusion instructional conditions. The influence of instruction on the foil trials makes this assumption questionable.