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Retrieval dynamics of the strength based mirror effect in recognition memory

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A B S T R A C T

The strength based mirror effect (SBME) refers to an increase in hit rates (HR) and a decrease in false alarm rates (FAR) for the test lists that follow a strongly encoded study list. Earlier investigation of accuracy and reaction time distributions by fitting the diffusion model indicated a mirror effect in the drift rate parameter, which was interpreted as an indication of more conservative responses due to a shift in the drift criterion. Additionally, the starting point for the evidence accumulation was found to be more liberal for the strong test lists. In order to further investigate this paradoxical effect of list strength on these two kinds of bias estimated from the diffusion model, we employed the response-deadline procedure which provided a direct assessment of response bias early in retrieval, prior to evidence accumulation. Results from the retrieval functions indicated more liberal response bias in the list strength paradigm with both pure- and mixed-strength study lists. On the contrary, the SBME was observed at the asymptotic accuracy, suggesting that the conservative response bias might be observed later in retrieval when memory evidence has fully accumulated. In addition, comparison of the SBME across pure and mixed lists revealed that the SBME was most prominent in the pure-list paradigm, suggesting that both the differentiation and criterion shift accounts jointly explain the SBME in recognition memory.

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Introduction

Episodic memory is often tested in the laboratory by presenting participants a list of items to study. In an item recognition task, participants are asked to endorse the items they have recently studied (targets) and reject the new items (foils). In recognition memory, when a list of items is strengthened via increasing the number of repetitions or manipulations during encoding, the probability to correctly endorse targets (hit rate) increase and the probability to incorrectly endorse foils (false alarm rate) decrease, producing a *strength based mirror effect* (SBME, Glanzer & Adams, 1985; Ratcliff, Clark, & Shiffrin, 1990; Stretch & Wixted, 1998). This subjective memory strength can be defined as a global match between the test item and traces in memory or alternatively as familiarity, based on the signal detection framework.

Previous research employed reaction time distributions to study the SBME. For instance, Criss (2010) and Starns, Ratcliff, and White (2012) applied the diffusion model (Ratcliff, 1978), a dynamic version of the signal detection framework, in a list-strength paradigm. In the diffusion model, memory evidence is assumed to accumulate over time and a response is given when enough evidence is accumulated towards one of the two responses ("yes" and "no") in an item-recognition task. The two responses are represented as two boundaries and the separation between the two boundaries can measure the speed-accuracy

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trade-off. The placement of the boundaries depends on the participant and can be manipulated by experimental conditions. For example, if the participants are instructed to give accurate responses rather than fast responses, they place their response boundaries far apart from each other and thus, giving a response requires more time and evidence is more likely to accumulate towards the correct response (Ratcliff, 1985). The *starting point* parameter measures the tendency towards one of the responses by indicating the point at which the evidence begins to accumulate towards one of the boundaries. For example, if the starting point is closer to the "no" boundary, the frequency of the "no" responses will be higher and the mean reaction time of the "no" responses will be shorter while the mean reaction time of the "yes" responses will be longer. The parameter that indicates the rate of evidence accumulation is the drift rate parameter (v). At each time point, the sampled evidence is compared to a criterion (*drift criterion*) and if the sampled evidence exceeds the criterion, evidence accumulates towards the "yes" boundary; if it fails to exceed the criterion, evidence accumulates towards the "no" boundary. In summary, there are three different types of criterion that determines the decisions made in the diffusion model: Boundary separation, starting point and the drift criterion.

Criss (2010) manipulated list-strength in item recognition and the parameters of the diffusion model showed that when speed-accuracy trade-off (boundary separation parameter) was taken into account, a mirror effect was observed in the drift rate parameters for the items tested in strong lists. The responses were more accurate and the average reaction time of the correct responses was faster for the foils tested along with strong targets (strong foils) compared with the responses of the foils tested along with weak targets (weak foils). Thus, faster and more accurate correct responses ("no") to the strong foils have produced lower drift rate (higher in absolute value) and the decrease in the drift rate has been interpreted as a decrease in the overall memory strength for the strong foils. This explanation depends on the differentiation mechanisms, which causes the foils to become less similar to the targets when items are strengthened during encoding. Accordingly, the differentiation models propose that foils that are compared to strong targets become less confusable at retrieval (Criss, 2006, 2009, 2010; Criss & McClelland, 2006; Criss et al., 2013).

The decrease in the drift rate of the strong foils could be alternatively interpreted as a shift in the drift criterion in the diffusion model (see Starns, Ratcliff, et al., 2012). That is because the drift rate is defined in relation to the drift criterion, as the distance from the drift criterion determines the drift rate. The exact placement of the drift criterion cannot be estimated in the diffusion model and it is arbitrarily set to the zero point of the drift rate. Starns, Ratcliff, et al. (2012) suggested that when items were strengthened during encoding, participants required more evidence to endorse the probe, thus the drift criterion shifts hypothetically to some positive value. In the diffusion model, this shift is manifested as faster accrual of evidence towards the "no" boundary, as the sampled evidence for the strong foils at each time step will more likely fail to exceed the drift criterion. In addition to the mirror effect observed in the drift rates, both studies reported that the starting point parameter was more liberal, meaning that participants were more biased towards the "yes" response boundary when tested with the strong targets.

Critical evidence for a shift in the drift criterion comes from the SBME observed when list strength is manipulated only during test (Starns, Ratcliff, et al., 2012; Starns, White, & Ratcliff, 2010; 2012). Different from previous studies in which strength was manipulated in pure lists (i.e. strength was manipulated across lists), Starns et al. presented participants with mixed lists of items (i.e. strength was manipulated within lists). However, in the subsequent test lists, either weak or strong targets were tested along with foils. The SBME observed in the drift rates after studying a mixed-list could only be explained by a shift in the drift criterion. That is because the memory evidence for foils after a mixed study list would be comparable across test strength conditions, and as a result, a decrease in the drift rates for strong foils would not be expected due to a differentiation mechanism. Similar to the findings from the pure-list paradigm, the starting point for evidence accumulation was closer to the "yes" boundary for strong targets.

In the current study, we tested whether list-strength has opposite effects on these two kinds of criterion, namely starting point and drift criterion. To do so, we employed the response-deadline speed-accuracy trade-off (SAT) procedure, which provides an in-depth investigation of different types of response bias by controlling for the speed-accuracy tradeoffs over the course of retrieval.

The response-deadline SAT procedure

The SAT procedure provides conjoint and unbiased measures of retrieval speed and retrieval success (Benjamin & Bjork, 2000; Hintzman & Curran, 1994; McElree & Dosher, 1989; Öztekin, Gungor, & Badre, 2012; Öztekin & McElree, 2007, 2010). In contrast to traditional reaction time measures, which are subject to speed-accuracy trade-offs and hence cannot provide pure measures of processing speed, by providing the full time-course of retrieval, SAT procedure yields independent assessment of accuracy and speed of processing (see McElree, 2006 for an overview). In SAT, participants are cued to respond with a response signal (a tone) presented at one of several time points, typically ranging from 60 to 3000 ms after the probe onset. The lag between the probe onset and the response signal is assigned randomly to test trials and participants are trained to give a response within 300 ms after the response cue. Although the diffusion model can also quantitatively account for the speed-accuracy trade-off by measuring the criterion to terminate the evidence accumulation (boundary separation), experimental manipulation of response deadline has the further advantage of providing the full time course of retrieval for each experimental condition, in addition to eliminating the bias related to speed-accuracy trade-off.

SAT retrieval functions can describe changes in accuracy as a function of total processing time, the total time that passes from probe onset to the response after the

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