Cognitive Psychology 95 (2017) 79–104

Contents lists available at ScienceDirect

Cognitive Psychology

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

Comparing different kinds of words and word-word relations to test an habituation model of priming

Cory A. Rieth [a], David E. Huber [b,*]

[a] Pacific Science and Engineering Group, Inc, United States
[b] University of Massachusetts, Amherst, United States

ARTICLE INFO

Article history:
Accepted 12 April 2017
Available online 28 April 2017

Keywords:
Neural network modeling
Repetition priming
Associative priming
Semantic priming
Perceptual identification
Synaptic depression
Neural habituation

ABSTRACT

Huber and O'Reilly (2003) proposed that neural habituation exists to solve a temporal parsing problem, minimizing blending between one word and the next when words are visually presented in rapid succession. They developed a neural dynamics habituation model, explaining the finding that short duration primes produce positive priming whereas long duration primes produce negative repetition priming. The model contains three layers of processing, including a visual input layer, an orthographic layer, and a lexical-semantic layer. The predicted effect of prime duration depends both on this assumed representational hierarchy and the assumption that synaptic depression underlies habituation. The current study tested these assumptions by comparing different kinds of words (e.g., words versus non-words) and different kinds of word-word relations (e.g., associative versus repetition). For each experiment, the predictions of the original model were compared to an alternative model with different representational assumptions. Experiment 1 confirmed the prediction that non-words and inverted words require longer prime durations to eliminate positive repetition priming (i.e., a slower transition from positive to negative priming). Experiment 2 confirmed the prediction that associative priming increases and then decreases with increasing prime duration, but remains positive even with long duration primes. Experiment 3 replicated the effects of repetition and associative priming using a within-subjects design and combined these effects by examining target words that were expected to repeat (e.g., viewing the target word 'BACK' after the prime phrase 'back to'). These results support the originally assumed representational hierarchy and more generally the role of habituation in temporal parsing and priming.

1. Introduction

Machine vision algorithms, such as the face detection software in digital cameras, take a snapshot image at a particular moment in time and then perform 'offline' calculations to determine the content of the image. However, rather than taking a discrete snapshot, biological vision involves continuous neural responses to continuously varying photoreceptor input. Furthermore, this continuous activity occurs in a staged hierarchical manner, with progressively more complex identification processes, progressing from low-level detection of dots and lines in specific retinal locations to high-level detection of

* Corresponding author at: Department of Psychological and Brain Sciences, 135 Hicks Way, University of Massachusetts, Amherst. Amherst, MA 01003, United States.

E-mail address: dehuber@psych.umass.edu (D.E. Huber).

http://dx.doi.org/10.1016/j.cogpsych.2017.04.002
0010-0285/

objects regardless of location (Hubel, 1988). Owing to the continuous nature of biological vision, there is a temporal assignment problem; in light of a constantly changing environment, identification processes need to determine whether a currently perceived feature is part of the currently viewed object versus a lingering response from a recently viewed object. To provide a concrete example, as you read each word of a sentence, you need to identify the letters of the currently viewed word without becoming confused by the letters of the most recently read word. Huber and O'Reilly (2003) proposed that neural habituation exists to solve this temporal assignment problem – by habituating to previously viewed objects, the features of prior objects are not confused with the current object.

In the lab, this temporal assignment problem is studied with Rapid Serial Visual Presentation (RSVP) paradigms (Potter & Levy, 1969). A stripped down version of RSVP presents just two stimuli in rapid succession (e.g., Duncan, Ward, & Shapiro, 1994; Hogben & Di Lollo, 1974), examining the effect of the first (the prime) on the second (the target). In the current study we used perceptual identification word priming to map out the dynamic time course of prime-target separation and we examined the manner in which this separation process differs for different kinds of letter strings, and for word pairs that are related in different ways.

For word priming, a briefly flashed prime word presented immediately before a related target typically results in better performance (i.e., faster and/or more accurate responses to the target). Reaction time distribution analyses support the hypothesis that priming benefits reflect source confusion about which letters/words appeared first versus second, with activation from the prime blending with the response to the target (de Wit & Kinoshita, 2015a; Gomez, Perea, & Ratcliff, 2013). However, the effect of this source confusion is offset, and even reversed (i.e., negative priming), if the prime is presented for a longer duration (Burt, Kipps, & Matthews, 2014; Huber, Shiffrin, Lyle, & Ruys, 2001; Huber, Shiffrin, Quach, & Lyle, 2002). This negative priming suggests an active discounting process designed to remove the unwanted effects of source confusion. Two complementary models of this discounting were developed, with each model capturing a different level of explanation (Marr, 1982): the Bayesian responding optimally with unknown sources of evidence (ROUSE) model (Huber et al., 2001) and a dynamic neural network model, nROUSE (Huber & O'Reilly, 2003). The Bayesian ROUSE model explains discounting as a near optimal perceptual decision and the nROUSE model assumes that neural habituation is the mechanism that implements discounting. Here we focus on the nROUSE model because it makes specific predictions for different prime durations. Next, we provide additional details regarding the behavioral paradigm used to measure these effects, and then we provide additional details of the nROUSE model.

1.1. Measuring blending and separation with immediate priming

The immediate effect of a prime word can be measured in a variety of ways, including reaction time in a lexical decision task (Meyer & Schvaneveldt, 1971; Meyer, Schvaneveldt, & Ruddy, 1974), naming latencies (Pecher, Zeelenberg, & Raaijmakers, 1998), and perceptual identification (Evett & Humphreys, 1981). Perceptual identification presents a target word very briefly followed by a mask. Participants are then asked to name the target word. The duration of the target is set separately for each individual to place accuracy at a threshold level (e.g., 75% correct identification). This task has some advantages over lexical decision for studying the perceptual separation of prime and target because it requires overt identification of the target, which directly assesses automatic processes (Pecher, Zeelenberg, & Raaijmakers, 2002). In contrast, lexical decisions are influenced by a sense of familiarity (Wagenmakers, Zeelenberg, Steyvers, Shiffrin, & Raaijmakers, 2004) or retrospective semantic matching (de Wit & Kinoshita, 2015b). Rather than asking participants to name the briefly flashed target word, control over the decision process is gained through a forced-choice decision, with accuracy providing the key measure of interest (Ratcliff & McKoon, 1997; Ratcliff, McKoon, & Verwoerd, 1989), although reaction time produces analogous results (Huber & Cousineau, 2004; Potter, Donkin, & Huber, submitted for publication).

Huber et al. (2001) examined immediate priming in a perceptual identification paradigm with forced-choice testing to determine if priming produces both costs and benefits. Fig. 1 presents a modified version of this procedure as used by Huber (2008) and the current experiments. After an initial fixation cross, a prime word was presented. On each trial, the duration of the prime was randomly chosen from one of five durations, ranging from a subliminal presentation (17 ms) to an excessively long presentation (2000 ms). The prime word was shown in a doubled up fashion (i.e., two copies of the prime word, with one on top of the other). This was done to provide some visual difference between prime and target for the case of repetition priming, although similar results are found when using lower case primes followed by upper case targets (see Experiments 2 and 3 of Huber et al., 2001). Participants were informed that the prime was just as likely to indicate the wrong answer as the right answer and this assertion was reinforced through trial-by-trial accuracy feedback. Thus, it was made clear that the prime was non-diagnostic (i.e., could not be used to help guess the correct answer). Immediately following the prime, a target word appeared for a duration set individually so that performance was 75% on average (i.e., at the perceptual threshold). After the target presentation, a pattern mask appeared, followed by a choice between the correct target word and an incorrect foil word. This response was non-speeded and accuracy was the measure of interest.

Using this procedure, Huber et al. (2001) observed both costs and benefits of priming as measured with identification accuracy. Furthermore, increases in prime duration caused a reversal in the pattern of costs and benefit. With short duration primes, repetition priming of the target (i.e., the 'target primed' condition) produced better performance as compared to a condition with unrelated choices (i.e., the baseline 'neither primed' condition). However, with repetition priming of the foil (i.e., the 'foil primed' condition), performance was worse than the baseline neither primed condition. This pattern describes 'positive priming' because priming either the target or the foil increased the likelihood that the participant would choose the