Acta Psychologica xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Acta Psychologica

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

Priming can affect naming colours using the study-test procedure. Revealing the role of task conflict

Dinkar Sharma

School of Psychology, Centre for Cognitive Neuroscience and Cognitive Systems, University of Kent, Canterbury, Kent CT2 7NP, United Kingdom

ARTICLE INFO

Article history:
Received 6 May 2016
Received in revised form 10 August 2016
Accepted 8 November 2016
Available online xxxx

Keywords:
Stroop effect
Implicit memory
Proactive control
Task conflict
Priming effect

ABSTRACT

The Stroop paradigm has been widely used to study attention whilst its use to explore implicit memory have been mixed. Using the non-colour word Stroop task we tested contrasting predictions from the proactive-control/task-conflict model (Kalanthroff, Avnit, Henik, Davelaar & Usher, 2015) that implicate response conflict and task conflict for the priming effects. Using the study-test procedure 60 native English speakers were tested to determine whether priming effects from words that had previously been studied would cause interference when presented in a colour naming task. The results replicate a finding by MacLeod (1996) who showed no differences between the response latencies to studied and unstudied words. However, this pattern was predominately in the first half of the study where it was also found that both studied and unstudied words in a mixed block were slower to respond to than a block of pure unstudied words. The second half of the study showed stronger priming interference effects as well as a sequential modulation effect in which studied words slowed down the responses of studied words on the next trial. We discuss the role of proactive and reactive control processes and conclude that task conflict best explains the pattern of priming effects reported.

1. Introduction

The Stroop paradigm has been developed to investigate how salient task-irrelevant stimuli can trigger failure of selective attention (Stroop, 1935; MacLeod, 1991). The Stroop task requires responding to the ink colour in which a word is written whilst ignoring the meaning of the word. The word can refer to colour or be a non-colour word (Klein, 1964). The general finding is that colour naming response latencies and accuracy are affected by the meaning of the word. Researchers have identified two types of conflicts that slow down responses. An informational conflict arises due to the contradictory information in the word and colour (e.g. when the word RED interferes with naming the ink colour green). A second type of conflict occurs between two potentially competing tasks (task conflict). For example, naming the ink colour (the relevant task) competes with the irrelevant but automatic word reading task (MacLeod & MacDonald, 2000; Kalanthroff, Goldfarb, & Henik, 2013; Kalanthroff, Goldfarb, Usher, & Henik, 2013). Task conflict occurs because certain stimuli become associated with certain tasks. For example, words are strongly associated with the task of reading and thus automatically activate the tendency to read written words (MacLeod & MacDonald, 2000).

Connectionist models have been developed to explain informational conflict (Cohen, Dunbar, & McClelland, 1990; Botvinick, Braver, Barch, Carter, & Cohen, 2001). At their core connectionist models involve competition between units in a response layer (response conflict). The response units are themselves activated by stimulus units from the input layer (word and colour input units). Informational conflict occurs due to the greater automaticity in reading words than responding to ink colours that is typically implemented as stronger connection weights between the word input layer and the response layer relative to the colour input layer and the response layer. A task demand layer is included to bias responses based on the instructed task goal. Depending on the task goal the network can bias responding to the ink colour or to the word.

Early models typically involved the flow of information from input to response in a bottom-up fashion. However, later models (e.g. the conflict monitoring model: Botvinick et al., 2001; and the dual mechanisms of control model: Braver, 2012; De Pisapia & Braver, 2006) introduced a proactive top-down control mechanism to maintain goal-relevant information. Botvinick et al. (2001) implemented proactive control by increasing activation to the task goal (usually the colour naming unit) in the task demand layer (see Fig. 1). Importantly they showed that proactive control could be activated by the degree of response conflict (measured using the Hopfield energy equation as the product of activation strength of competing responses from the response layer). Empirical support for this mechanism comes from several sources. In the sequential modulation effect (aka the Gratton effect) incongruent trials (e.g. the word RED written in green ink) are responded to more quickly when the previous trial is also incongruent than when congruent

E-mail address: d.sharma@kent.ac.uk.

http://dx.doi.org/10.1016/j.actpsy.2016.11.004
0001-6918/© 2016 Published by Elsevier B.V.

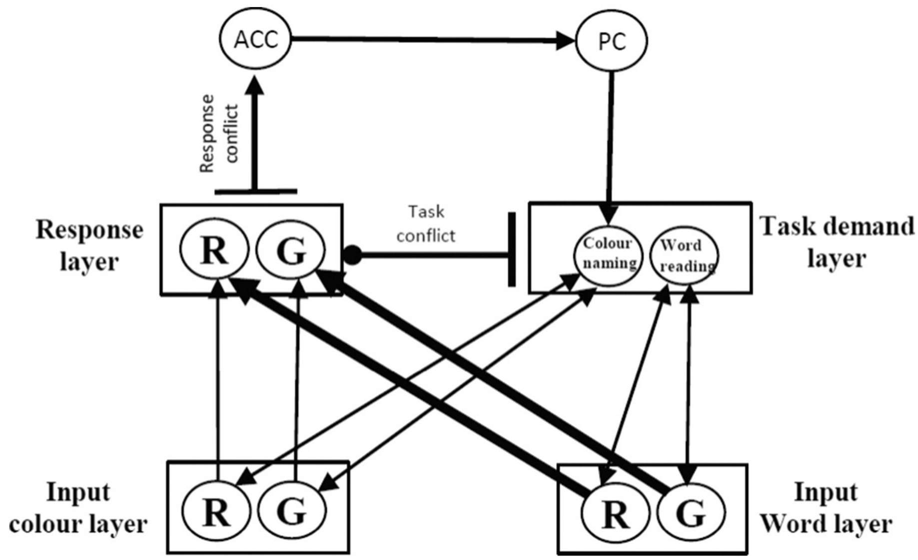

Fig. 1. Proactive-control/task-conflict (PC-TC) model. Adapted from Kalanthroff, Avnit, Henik, Davelaar, and Usher (2015). Task conflict is represented as the inhibitory connection between the task demand layer and the response layer. Response conflict triggers additional activation via the anterior cingulate (ACC) unit to modulate top-down the activation of the colour naming unit as in Botvinick et al. (2001). R = red, G = green.

(Gratton, Coles, & Donchin, 1992; Kerns et al., 2004; Botvinick et al., 2001). In the proportion congruency effect increasing the number of colour word trials can decrease interference (Tzelgov, Henik, & Berger, 1992). Furthermore, Padmala, Bauer, and Pessoa (2011) have shown that negative stimuli can reduce the sequential modulation effect that indicates a reduced level of top-down proactive control. Support also comes from other studies using non-colour words such as negative emotional words. In the slow effect (McKenna, 1986; McKenna & Sharma, 2004; Algom, Chajut, & Lev, 2004; Phaf & Kan, 2007) a negative emotional stimulus triggers a relaxation in maintaining the colour naming goal to increase response latencies on subsequent emotionally neutral trials (Wyble, Sharma, & Bowman, 2008).

In the proactive-control/task-conflict (PC-TC) model (Kalanthroff et al., 2015) additional features are added to implement the effects of task conflict (see Fig. 1). Task conflict is implemented as an inhibitory connection between the task demand layer and the response layer. The amount of inhibition is modelled as the strength of competition between the word reading and colour naming task demand units (again measured using the Hopfield energy equation as the product of activation strength of competing task demand units). In addition, bilateral connections between the task demand layer and the stimulus (colour and word) input layer are added to enable a level of reactive control.

To illustrate the workings of the model with respect to task conflict Kalanthroff et al. (2015) describe how when proactive control (PC) to colour naming is high the task demand colour naming unit is given additional activation top-down and thus the influence of bottom-up connections into the task demand units is negligible. However, when PC to colour naming is low this allows the bottom-up connections from the word input units to the word reading units to increase competition in the task demand layer and thus inhibit units in the response layer. One of the predictions of this task conflict mechanism is that the response latency to incongruent and congruent trials is increased when PC is low than when PC is high. The prediction that there is increased interference (longer reaction times to incongruent than a nonword control trial) and a reversed facilitation (i.e. longer response latencies to a congruent trial than a nonword, XXXX, trial) effect under low PC conditions has been recently supported (Goldfarb & Henik, 2007; Kalanthroff, Goldfarb, & Henik, 2013; Kalanthroff, Goldfarb, Usher et al., 2013; Kalanthroff & Henik, 2014; Kalanthroff et al., 2015). Although not previously considered it is interesting to note that in the PC-TC model when word reading is activated proactively, inhibition (as task conflict) is high and any reactive control is negligible. Only when PC to word reading is low will there be an influence of task conflict that is reactive to the stimulus inputs.

Although the Stroop task has been predominately used to examine attentional processes (Cohen et al., 1990), it has also been used to investigate memory. The main aim of this study was to explore the extent to which memory processes could be investigated using a Stroop like task as an indirect measure of memory. One way in which this has been done is by investigating the role of priming in the non-colour word Stroop task (MacLeod, 2005). Priming is a typical method used to investigate implicit memory as the influence of previously studied items can be seen on subsequent colour naming test trials. To investigate priming in the Stroop task non-colour words are typically used as distractors during testing. These distractors can be from a previously studied word set or a new unstudied set of words. Any difference in response time to name the colour of the studied and unstudied words is often attributed to implicit memory processes. The intuition that studied words will distract more than unstudied words and thus produce slower response latencies on a colour naming task has been validated in a number of studies (Warren, 1972, 1974, Conrad, 1974; Henik, Kellogg, & Friedrich, 1983; Whitney, 1986, Whitney & Kellas, 1984). Though see also Burt (1994, 1999, 2002) for situations that can produce facilitation.

Burt (2002) discussed how priming effects could be considered in connectionist models. Early connectionist models did not incorporate a task conflict mechanism therefore Burt resorted to explaining priming effects as increased competition in the response layer (the response conflict hypothesis). Burt speculated that expanding the number of units in the response layer to include non-colour word units might allow studied words to compete more strongly than unstudied words. Burt also suggested that priming facilitation could not be explained by the connectionist models and suggested decreased competition when repeating a prime word during test (e.g. due to expectancy) to explain facilitation.

Since the role of task conflict has not been considered in previous research on priming it is possible that priming could also be due to task conflict. In the PC-TC model task conflict occurs because of the competition in the task demand layer between colour naming and word reading and the resulting inhibition of the response layer. If it is assumed that studied words (compared to unstudied words) produce greater activation of the word reading task demand unit then the PC-TC model predicts greater competition in the task demand layer and hence greater

Please cite this article as: Sharma, D., Priming can affect naming colours using the study-test procedure. Revealing the role of task conflict, *Acta Psychologica* (2016), http://dx.doi.org/10.1016/j.actpsy.2016.11.004