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Contingency learning without awareness: Evidence for implicit control ☆

James R. Schmidt [a,*], Matthew J.C. Crump [b], Jim Cheesman [c], Derek Besner [a]

[a] Department of Psychology, University of Waterloo, 200 University Ave. W., Waterloo, Ont., Canada N2L 3G1
[b] Department of Psychology, McMaster University, Canada
[c] Department of Psychology, University of Saskatchewan, Canada

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Abstract

The results of four experiments provide evidence for controlled processing in the absence of awareness. Participants identified the colour of a neutral distracter word. Each of four words (e.g., MOVE) was presented in one of the four colours 75% of the time (Experiments 1 and 4) or 50% of the time (Experiments 2 and 3). Colour identification was faster when the words appeared in the colour they were most often presented in relative to when they appeared in another colour, even for participants who were subjectively unaware of any contingencies between the words and the colours. An analysis of sequence effects showed that participants who were unaware of the relation between distracter words and colours nonetheless controlled the impact of the word on performance depending on the nature of the previous trial. A block analysis of contingency-unaware participants revealed that contingencies were learned rapidly in the first block of trials. Experiment 3 showed that the contingency effect does not depend on the level of awareness, thus ruling out explicit strategy accounts. Finally, Experiment 4 showed that the contingency effect results from behavioural control and not from semantic association or stimulus familiarity. These results thus provide evidence for implicit control.

Keywords: Contingency learning; Stroop; Word recognition; Proportion congruent; ISPC; Control; Automaticity; Implicit learning; Subjective awareness; Objective awareness

1. Introduction

Cognitive processes that are controlled are conventionally assumed to operate in a slow, effortful, and voluntary manner (Posner & Cohen, 1984; Posner & Snyder, 1975; Shiffrin & Schneider, 1977). Thus, when researchers discuss the influence of ''controlled'' processes, it is typically assumed that such processes are

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* Corresponding author.
E-mail address: j4schmid@watarts.uwaterloo.ca (J.R. Schmidt).

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explicit (i.e., conscious; cf., Besner & Stolz, 1999). As such, the term ''implicit control'' would seem to be nonsensical, because ''implicit'' (i.e., unconscious) seems to preclude the possibility of control. However, etymologically speaking this is not a necessary conclusion. The Oxford English Dictionary (2001) defines control as ''the power to influence people's behaviour or the course of events.'' Similarly, Merriam-Webster (2005) defines control as the ''power or authority to guide or manage.'' Nothing in these definitions necessitates conscious intent. Whether implicitly controlled processes are actually observable is an empirical question. As the experiments reported here demonstrate, control can be dissociated from consciousness.

Evidence for cognitive control, which is assumed to be explicit and strategic in nature, has been drawn from the Stroop literature (Stroop, 1935). In the Stroop task, identification of the print colour of colour words is slower when the word and ink colour are incongruent (e.g., the word GREEN in orange; $\text{GREEN}_{\text{orange}}$) than when they are congruent (e.g., $\text{ORANGE}_{\text{orange}}$; see MacLeod, 1991, for a review). Probably the most important demonstration of putatively controlled processes in the Stroop literature is the proportion-congruent effect. The proportion-congruent effect refers to the finding that the size of the Stroop effect is influenced by the proportion of congruent items in a block of trials (Lindsay & Jacoby, 1994; Logan & Zbrodoff, 1979). Specifically, the Stroop effect is much larger in a high proportion-congruent block of trials than in a low proportion-congruent block of trials. This effect is commonly attributed to participants explicitly learning to predict the colour from the word. Specifically, because the word usually matches the colour in a high proportion-congruent block of trials, participants can capitalize on this relationship and predict the colour based on the word (e.g., if the word is BLUE, then the colour is probably blue), thus leading to a larger Stroop effect because responses would be especially fast on the expected congruent trials and especially slow for the infrequent incongruent trials. In contrast, the Stroop effect is reduced in a low proportion-congruent block of trials, because participants can learn that the word rarely predicts the correct response and therefore there is no payoff that leads to fast responses on congruent trials and large costs on incongruent trials. This has often been explained in terms of a deliberate, task-wide strategy.

The idea that cognitive control over the amount of Stroop interference requires a task-wide strategy has recently been challenged. In the item-specific proportion-congruent (ISPC) manipulation participants are presented with high and low proportion-congruent stimuli within the same block. This is accomplished by presenting some words (e.g., BLUE and GREEN) mostly with their congruent colour (e.g., BLUE is presented 75% of the time in blue and 25% of the time in green) and other words (e.g., YELLOW and ORANGE) mostly with incongruent colours (e.g., YELLOW is presented 25% of the time in yellow and 75% of the time in orange). The Stroop effect is still larger for high proportion-congruent words relative to low proportion-congruent words (Jacoby, Lindsay, & Hessels, 2003; Trainham, Lindsay, & Jacoby, 1997). This ISPC effect indicates that the ''strategy'' participants use is not (at least always) task-wide (i.e., participants cannot simply predict that the words will match the colours, because this only applies to the high proportion-congruent words). Rather, participants may generate a contingency estimate associated with each word (e.g., BLUE likely indicates the colour blue, whereas YELLOW likely indicates orange).

Although it is possible that participants could be predicting *congruency* with the word (e.g., BLUE likely indicates a matching colour, whereas YELLOW likely indicates a mismatching colour), it is probably more likely that participants use the word to predict a specific colour response. Thus, for instance, if BLUE is presented most often in blue, then BLUE will indicate a blue verbal or key press response. Similarly, if ORANGE is presented most often in yellow, then ORANGE will indicate a yellow verbal or key press response. Thus, participants may be using the *contingencies* between words and colours to predict a *specific response* rather than congruency in general. In support of this contention, Musen and Squire (1993) demonstrated contingency learning independent of any congruency relations between the words and colours. In their Experiment 2, they paired each of seven arbitrary words (e.g., SOCKS) with a colour. Words were always presented in their assigned colours, but participants were instructed to ignore the word and respond to the colour. Halfway through the experiment the words were re-paired with new colours without notice. This led to an increase in response latencies. Thus, participants learned the *contingencies* (i.e., not congruency) between the arbitrary words and the colours and used these to facilitate responding.

One methodological concern with Musen and Squire's (1993) design is that the words are perfectly correlated with the responses. Thus, it is difficult rule out the possibility that some or all of the participants were making responses by identifying the word rather than the colour, thus leading to significant impairment in