Comparing Interference And Facilitation Models

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1 Abstract: The PWI Effect is a Stroop Effect

Leendert van Maanen, and Hedderik van Rijn. *The Picture-Word Interference Effect is a Stroop Effect After All.* 2007

It has been widely accepted that Picture-Word Interference (PWI) and the Stroop effect are different manifestations of the same process. However, there have been recent suggestions that their loci differ, making them not stem from the same process after all. Van Maanen and Van Rijn argue that on the contrary, using a variation of one parameter both effects can be produced by the same model.

PWI arises when subjects are shown a picture of both an object and a word. This word is similar in the congruent case (a picture of a dog with the word dog), unrelated in the neutral case (a picture of a dog with the word apple) and contradictory in the incongruent case (a picture of a dog with the word cat). In one test participants are asked to name the picture, with as general result that timing is increased for the incongruent case (interference) and decreased for the congruent case (facilitation), compared to the neutral situation. The effect does not arise when subjects are asked to read the word instead, with similar reaction times in all cases.

The stroop effect is tested by showing subjects a series of words in different colors, asking them to name the color, not the word. In the congruent case the color of the word equals the word (the word red written in red), in the neutral case participants name the color of a blob and in the incongruent case the word is not equal to the color (the word blue written in green). The congruent case is again slightly faster than the neutral case, and the incongruent case is slightly slower. Likewise, when participants are asked to read the word instead of naming the color, no change in reaction times is observed.

Recent studies based dual task performance using a Stimulus Onset Asynchrony (SOA) provide evidence that the locus (lit. place) of the Stroop effect is on the level of response selection, occurring relatively late in the processing stream. A similar study for PWI however found its effect on level with what is most likely the perceptual encoding of the stimulus far earlier in the processing stream than the stroop effect. From this result is argued that the loci of both effects differ, and thus both effects do not arise from the same process after all.

Van Rijn and Van Maanen build a model based on ACT-R using RACE as declarative memory retrieval system that effectively mimics the observed behavior for both the Stroop and PWI effects. They show that by varying the speed of processing for the presented stimuli, a plausible assumption since line drawings are more complex stimuli than colors, the constructed model both fits the data as well as shows the theorized shift in locus from the perceptual encoding phase for the PWI effect to the response selection phase for the stroop effect, making it plausible both effects do originate from the same principle.

2 Abstract: On Control of Automatic Processes

Jonathan D. Cohen, Kevin Dunbar, and James L. McClelland. On the Control of Automatic Processes: A Parallel Distributed Processing Account of the Stroop Effect. *Psychological Review*, 97(3):332-361, 1990.

Traditional views of automaticity treated it as an all-or-none phenomenon, where automatic processes are independent of attention and controlled processes are not. Empirical data, as obtained by stroop-task experiments, suggest that this view is incorrect.

A modular parallel distributed processing model is developed, with pathways between units whose strength is adjusted by learning through a combination of backpropagation (Rumelhart, Hinton, & Williams, 1986) and the cascade mechanisms described by McClelland (1979), wherein information is represented as a pattern of activation. A logistic function for time averaged activation introduces non-linearity into processing and normally distributed noise added to the net input of each unit simulates variability in responses.

With the Stroop task as example the model then simulated time course of processing as well as the effects of learning, demonstrating automatic processes to be continuous and emerge gradually with practice.

Also simulated was the effect of a SOA in stimulus presentation, which showed little interference of color on word regardless of SOA, suggesting that differential speed of processing is not the sole source of interference observed in the Stroop task and that interference is substantially influenced by differences in strength of processing.

When the model was trained, its learning curve did only follow a power-law after meaningful and moderately strong connections from input units to intermediate units were already in place, suggesting constraints on the power-laws applicability to certain types of learning. The effect of practice on interaction with color naming is examined: only after an *indirect pathway* was added did the model comply with observed data, suggesting the existance of a general-purpose module used initially for new tasks untill sufficient pathway strength is achieved.

Thus is shown how mechanisms in a simple network-based model can explain many of the phenomena associated with attention and automaticity. A common explanation for empirical data is obtained in terms of the strength of processing pathways, providing a basis for learning, the time course of processing and the influence attention has on interference effects which is presented in contrast to other current models. The notion that processes are either controlled or automatic is discarded as evidenced by data on interference effects, making place instead for a continuous spectrum of direct/indirect pathway processes, all subject in some degree to attentional control. It is suggested that more attentional control is required for less direct processes, slowing their repsonse.

By limiting each module to a single representation, the effect of two disparate signals is shown a capacity limit for that module or resource and causing interference, suggesting ways to characterize the notion of capacity in greater detail. The mechanisms used show how the principals of continuous processing can be applied to the study of attention and the control of direct processes.

3 Discussion

Both Van Maanen and Van Rijn as well as Cohen, Dunbar, and McClelland offer a computational model explaining the Stroop effect. While both models agree on most basic principals, such as limited processing capacity in a single node causing interference in a generally distributed system, they offer different explanations for the general cause of this interference or facilitation.

Basis to the model by Cohen, Dunbar and McClelland is the notion that interference is caused by differences in pathway strength between nodes. If the pathways for one task are stronger it will cause interference or facilitation for a less practiced task yet vice versa this is not the case. This view seems to be supported by empirical data which suggests that a new task is first less strong and thus suffers from interference, but with enough practice can become automatic enough to cause interference itself. Based on earlier research which suggested color naming interference was independent of SOA (Stimulus Onset Asynchrony) they claimed speed of processing to be less relevant for this task.

Van Maanen and Van Rijn based their model on the assumption that the differences in the PWI (picture-word interference) effect and Stroop effect could be accounted for by a variant in the speed of processing of their respective stimuli, in response to research by Dell'Acqua (2007), which claimed PWI was not a stroop effect after all since for large SOA the PWI effect did arise, placing the locus of this effect far earlier in the processing stream than the locus for the Stroop effect. Van Maanen and Van Rijn offer a plausible explanation for this observation using the assumption that line drawings have a lower speed of processing than simple blobs of color.

While findings by Dell'Acqua are to a large extent consistent with Cohen, Dunbar and McClelland, so too is the model by Van Maanen and Van Rijn in turn able to explain the observations made by Dell'Acqua. Provided the assumption made by Van Maanen and Van Rijn that processing speed of a line drawing is lower, which they provide ample evidence for, these models are not as mutually exclusive as they initially appear to be. While Van Maanen and Van Rijn offer a viable answer to the question of when and where, so too do Cohen, Dunbar and McClelland give a fair explanation for the why and how.

In conclusion, combining the given research both PWI and Stroop effects can be explained: they occur at different locations because of their difference in processing speed, as suggested by Van Maanen and Van Rijn, and they occur at those locations because one task is more practiced than the other, which caused a change in pathway strength as suggested by Cohen, Dunbar and McClelland.