Windows to cognitive control

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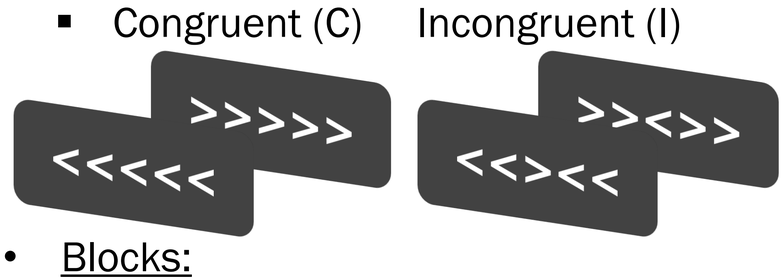
Introduction

Incongruent trials, which elicit response conflict, are generally faster when the trial is preceded by an incongruent trial. Extensive previous research has shown that this type of conflict adaptation can be exerted on-the-fly (e.g., Gratton effect), or in a more sustained way (e.g., by tracking the amount of block wide encountered conflict). Nevertheless, research on the exact reach of conflict adaptation is scarce (but see Horga, et al, 2011). Inspired by reinforcement learning models, we computed the effect of conflict history (i.e., conflict experienced on the previous five trials) on performance on the current trial. This allowed us to establish a "window" in which cognitive control operates. The size of the window is determined by the degree to which preceding trials affect performance on the current trial. A small window is indicated when only the previous trial affects the current trial response (e.g., the Gratton effect). A larger window is indicated when more distant trials affect current responses. We explored window sizes in blocks with varying proportion congruency and volatility.

Method

- Task: Arrow flanker (*N*=42)
- Stimuli:
  - Congruent (C) Incongruent (I)



- Blocks:
  1. Neutral (50% C)
  2. Mainly congruent (MC, 75% C)
  3. Mainly incongruent (MI, 25% C)
  4. Volatile (% congruency switches every 20 trials, e.g.: 75% of the first 20 trials are C, 25% of the next 20 trials are C, etc.)

Repeated Measures ANOVA

• Block	$p = .005$
▪ MC vs. Neutral	$p = .007$
▪ MC vs. MI	$p = .01$
▪ Volatile vs. Neutral	$p < .001$
▪ Volatile vs. MI	$p = .02$
• Trial distance	$p < .001$
• Block*Regressor	$p = .57$

Results

Fitted model:

$$RT = \beta_0+\beta_1C_n+\beta_2C_{n-1}+\beta_3C_{n-2}+\beta_4C_{n-3}+\beta_5C_{n-4}+\beta_6C_{n-5}+\beta_7C_nC_{n-1}+\beta_8C_nC_{n-2}+\beta_9C_nC_{n-3}+\beta_{10}C_nC_{n-4}+\beta_{11}C_nC_{n-5}$$

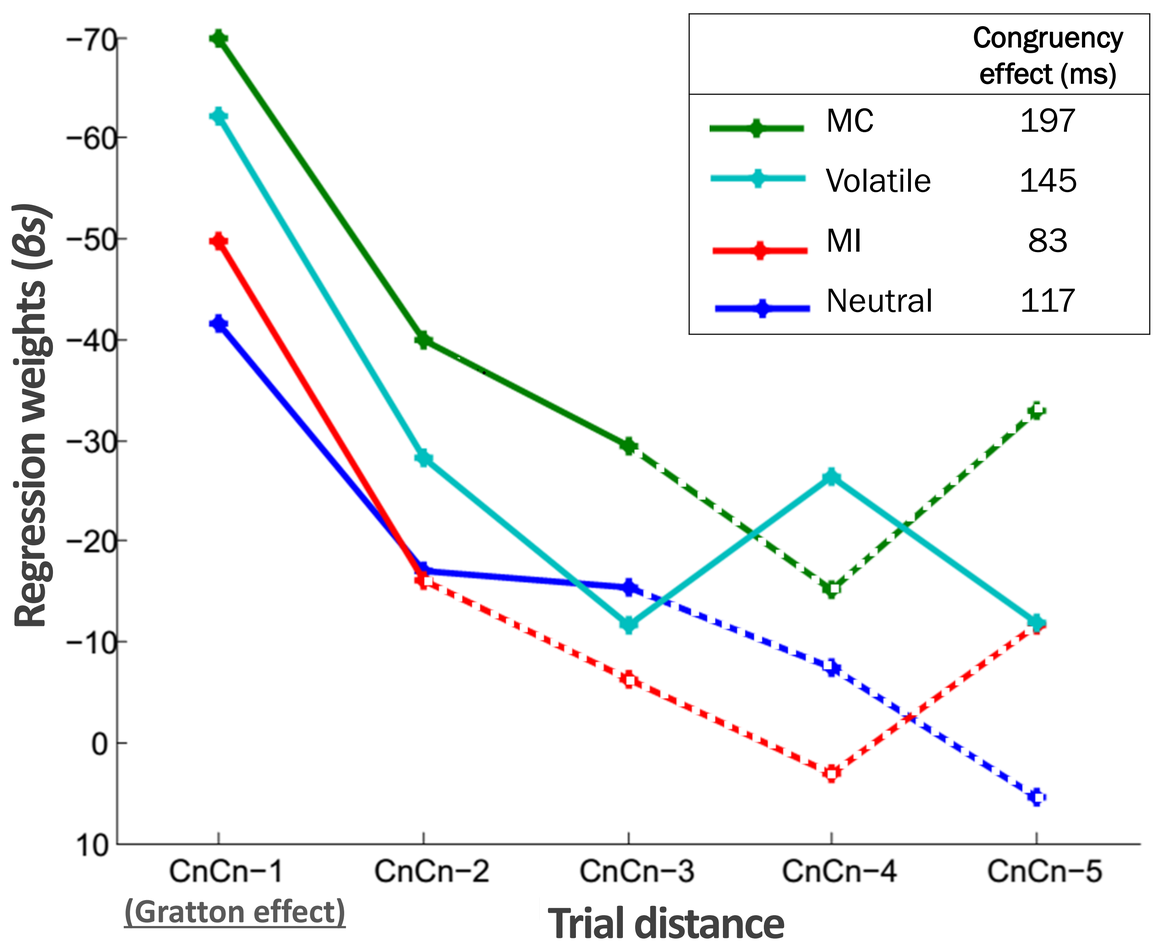


Figure. Regression weights for the interaction between congruency of trial n and congruency of trial n-i.
Cn = congruency of the current trial, Cn-1 is congruency of the previous trial, etc.
Solid line = Post-hoc tests revealed regression weight significantly < 0 ($p < .05$)

Discussion

Performance on the current trial was not only affected by conflict on the preceding trial but also by more distant trials, ranging two to four trials back (see solid lines on the figure). Furthermore, conflict adaptation was largest in the MC and volatile blocks, suggesting that in these blocks, conflict on previous trials resulted in the largest adaptation on the current trial. Although adaptation decreased with increasing trial distance in all conditions, the ratio of decrease was similar in all blocks (i.e., no interaction between block and regressor, suggesting similar slopes in the figure). In other words, neither proportion congruency nor the volatility of the block affected window size. These results show that our method offers a valid way to study the effects of conflict history on current performance, and that this history extends beyond the previous trial. In addition, reliance on conflict history does not seem to vary for different levels of proportion congruency or volatility.

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